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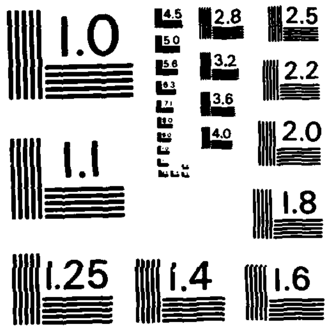

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Installation Restoration Program

AD-A162 365

Final Report
Phase II, Stage 1 - Problem Confirmation Study
Norton Air Force Base
San Bernardino, California

Volume I - Technical Report

Prepared For:

United States Air Force
Occupational and Environmental Health Laboratory (OEHL)
Brooks Air Force Base, Texas

July 1985

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A Phase II Stage 1 Field evaluation was conducted at Norton Air Force Base, San Bernardino, California, under the auspices of the U.S. Air Force Installation Restoration Program (IRP). The evaluation was accomplished by Roy F. Weston, Inc. (WESTON) as authorized by Task Order 0021 of Air Force Contract No. F 33615-80-D-4006. Fifteen sites of potential environmental concern, grouped into six waste management zones, were evaluated. A total of 22 monitor wells were installed and groundwater samples were obtained from each well. Soil samples were obtained for chemical analysis from 12 soil borings. Samples of surface water, bottom sediments and fish tissues were obtained from three ponds. All chemical analyses were accomplished in accordance with Standard USEPA analytical methods. Based on the sampling and analyses performed, levels of contamination were found in soils or

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groundwater at seven of the 15 sites evaluated which warrant further investigation and potential remedial actions. Recommendations were made as to appropriate follow-up site evaluation work at these seven sites.

INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
STAGE 1

FINAL REPORT

FOR

NORTON AIR FORCE BASE
SAN BERNARDINO, CALIFORNIA

16 JULY 1985

PREPARED BY

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This report has been prepared for the United States Air Force by Roy F. Weston, Inc. for the purpose of aiding in the implementation of the Air Force Installation Restoration Program. It is not an endorsement of any product. The views expressed herein are those of the contractor and do not necessarily reflect the views of the publishing agency, the United States Air Force, nor the Department of Defense.

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PREFACE

The purpose of the Report is to document the accomplishment of the Phase II Stage 1, Problem Confirmation Study of the United States Air Force Installation Restoration Program (IRP) at Norton Air Force Base, San Bernardino, California. This work was conducted by Roy F. Weston, Inc. under Contract No. F33615-80-D-4006, Task Order 0021.

Mr. Peter J. Marks is Program Manager for this Contract. Dr. Frederick Bopp III managed this Task Order. Laboratory analyses were accomplished at WESTON's Laboratory in West Chester, Pennsylvania, under the supervision of Dr. James S. Smith and Dr. Theodore F. Them. Roy F. Weston, Inc. wishes to acknowledge Capt. Cedric Daksla, USAF, Norton Air Force Base Bioenvironmental Engineer, for his kind assistance in conducting this project.

This work was accomplished during the period November, 1983 and August, 1984. Major Dennis D. Brownley, USAF, BSC, Technical Services Division USAF Occupational and Environmental Health Laboratory (USAF OEHL/TS) was the Technical Monitor.

Approved

Peter J. Marks
Program Manager

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EXECUTIVE SUMMARY

ES-1.0 INTRODUCTION

Roy F. Weston, Inc. (WESTON) was retained by the U. S. Air Force Occupational and Environmental Health Laboratory (OEHL) under Contract No. F33615-80-D-4006 to provide general engineering, hydrogeological and analytical services. These services were applied to the Installation Restoration Program (IRP) Phase II effort at Norton Air Force Base under Task Order 21 of this contract.

In 1976 the Department of Defense (DoD) devised a comprehensive Installation Restoration Program (IRP). The purpose of the IRP is to assess the potential migration and control the actual migration of environmental contamination that may have resulted from past operations and disposal practices on DoD facilities. In response to the Resource Conservation and Recovery Act of 1976 (RCRA) and in anticipation of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA or "Superfund"), the DoD issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM) dated June, 1980 (DEQPPM 80-6) requiring identification of past hazardous waste disposal sites on DoD agency installations. The U.S.Air Force implemented DEQPPM 80-6 by message in December, 1980. The program was revised by DEQPPM 81-5 (11 December 1981) which reissued and amplified all previous directions and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 by message on 21 January 1982. The Installation Restoration Program has been developed as a four-phase program as follows:

- Phase I - Problem Identification/Records Search
- Phase II - Problem Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Corrective Action

Only the Phase II Stage 1 portion of the IRP effort at Norton Air Force Base was part of this Task Order.

ES-2.0 SCOPE OF WORK

Norton AFB (NoAFB) is located in the San Bernardino Valley on the southeast side of the city of San Bernardino in Southern California. NoAFB was activated in 1942 and has

served as a major overhaul center for jet engines and a general aircraft repair center. Since 1962, NoAFB has served as a Military Airlift Command (MAC) Base.

Industrial activities at NoAFB have resulted in the occurrence on the installation of a number of waste disposal sites identified in the Phase I Records Search. The field investigation performed under Task Order 21 included 15 sites organized into 6 waste management zones. These sites and zones are shown in Figure ES-1. These were the sites identified in Phase I as having a high or moderate potential for immediate hazard or contaminant migration. The remaining sites will be investigated during Stage 2 of the Phase II investigation.

The scope of the initial Phase II Stage 1 Confirmation investigation included: performance of Ground Penetrating Radar survey at four sites in Zone 1; drilling and sampling of 12 soil borings; drilling, construction and sampling of 22 monitor wells; sampling of 3 ponds in Zone 1 for surface water, bottom sediment and fish tissue; an elevation survey of monitor well casings and a round of depth to water measurements; preparation of water level maps for the Base as a whole and the individual Zones; interpretation of lithologic, hydrogeologic and chemical data; and preparation of this final report. Soil and water quality analyses were performed in WESTON's California and Pennsylvania laboratories in accordance with USEPA approved methods.

ES-3.0 MAJOR FINDINGS

Only one site was indicated by the GPR survey to require further investigation: Site 3, Waste Pit No. 2, near the Golf Course Parking Lot. Based on the sampling and analyses performed, levels of contamination were found in soils and groundwater warranting further investigation at nine of the fifteen sites investigated, and possible future remedial actions.

Soils were found to be contaminated with VOA compounds at significant levels at both sites in which soil borings were performed. Fuel derivatives and chlorinated hydrocarbons were the principal contaminants in soil at Site 5, Fire Protection Training Area No. 2; chloro- and dichlorobenzene were the principal contaminants at Site 17, Drummed Waste Storage Area No. 3 and the Waste Fuel and Solvent Sumps in the IWTP compound.

The major groundwater contaminants indicated by available data are volatile organic (VOA) compounds. At least one VOA compound was found in excess of 0.050 mg/l in five monitor

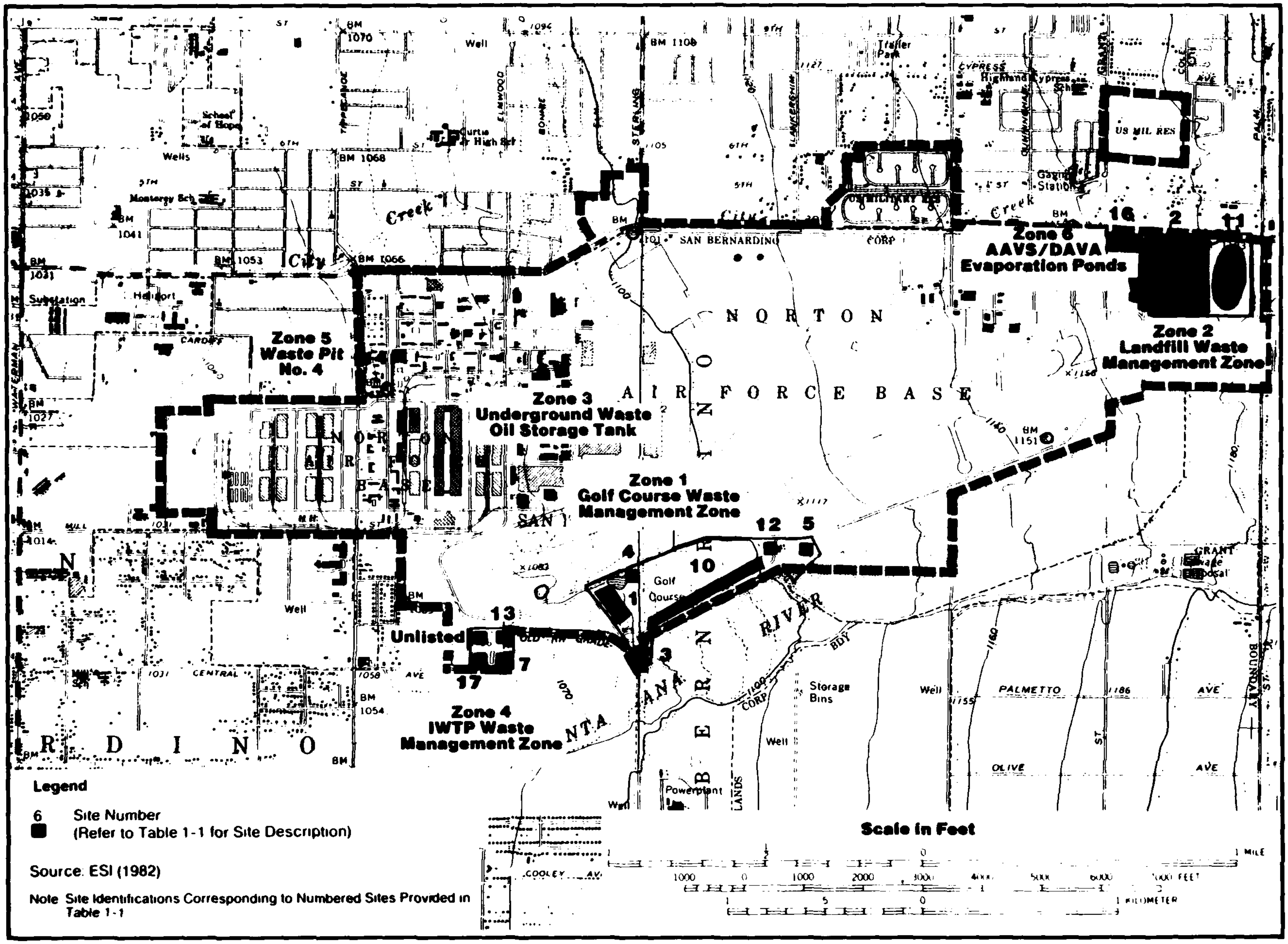


FIGURE ES-1 LOCATION OF PHASE II INVESTIGATION SITES AT NORTON AFB

wells. Many of these VOA compounds are halogenated hydrocarbons, for which TOX serves as an indicator parameter. TOX levels in those same wells ranged from 0.051 to 0.288 mg/l.

Of the dissolved metals analyzed in groundwater, Cr, Ni, Cd, Zn, Hg and Li, were not detected in any wells. Lead (Pb) was detected at levels ranging from 0.06 to 0.43 mg/l in five wells. Arsenic was detected at a level of 0.35 mg/l in a single well.

No significant contamination of bottom sediment or water in the three Golf Course ponds sampled is indicated by available data. Fish tissue results for metals were within normal ranges for pelagic fish from other waters.

ES-4.0 CONCLUSIONS

Based upon the results of the Phase II, Stage 1 Confirmation Study conducted at Norton AFB, the following key conclusions have been drawn:

1. Groundwater in the principal valley aquifer occurs under shallow water-table conditions in the eastern and northeastern half of the Base, and under semi-confined conditions in the western and southwestern half. In the western and southwestern half, the principal aquifer is overlain by a shallow water-table aquifer approximately 5 to 20 feet thick, and separated from it by a silt and sandy silt zone from 3 to 12 feet thick.

2. Regional groundwater flow beneath the Base in the principal aquifer is to the west-southwest, approximately parallel to direction of the Santa Ana River, along an average hydraulic gradient of 0.008. Flow velocity in the principal aquifer is estimated to be relatively high (on the order of 10 feet/day) based on the permeable nature of the Tertiary and Quaternary alluvium underlying the valley. The regional flow direction may be affected locally by pumping in the principal aquifer from high-capacity production wells both on and off-Base.

3. Flow direction in the shallow water-table aquifer along the southern and southeastern boundary is undetermined at this time, and may vary considerably during the course of the year. In July 1984, flow appeared to be occurring to the northwest, away from the Santa Ana River channel.

4. The influence of pumping wells screened in the principal aquifer represents the most likely potential for off-Base migration of contaminants. The location of major supply wells, both on and off-Base, is shown in Figure 2-6. The Gage Canal Company well field, located just off-Base between Zone 4 and the Santa Ana River channel, represents the most likely receptor for contaminants migrating off-Base.

5. The results of the GPR survey indicate that several apparent areas of disturbed subsoil exist in Zone 1, but that some of these areas may actually represent buried remnant channels of the Santa Ana filled with coarse, bouldery sediments. The most likely area of buried fill is Site 3, Waste Pit No. 2, in the Golf Course Parking Lot.

6. On the basis of groundwater and pond results, there do not appear to be significant levels of environmental contamination at most sites in Zone 1. The only Zone 1 sites considered for further investigation in the IRP are Site No. 3 (Waste Pit No. 2) on the basis of the GPR survey and the high specific conductance in MW-3, and Site No. 5 (Fire Protection Training Area No. 2) on the basis of the soil boring results. Soil contamination was encountered in all six borings at Site No. 5, primarily with fuel-derivative volatile organic compounds in the 1 to 100 ug/g range, and secondarily with volatile chlorinated hydrocarbons in the 0.01 to 0.015 ug/g range. Four of the sites in this Zone have been buried since 1960, and are located either directly beneath ponds or under heavily irrigated portions of the Golf Course. It is likely that any contaminants originally present in these sites have been dispersed by

the high rates of percolation presumably associated with Golf Course irrigation, which would account for the relatively low levels of contaminants observed in monitor wells MW-1 through MW-8. No further action is warranted at Sites 10 and 12 in Zone 1.

7. On the basis of groundwater results for MW-11 through MW-13, there do not appear to be significant levels of environmental contamination requiring remedial action in Zone 2, the Landfill Waste Management Zone.

8. On the basis of groundwater results for MW-15, there appears to be significant contamination of groundwater in Zone 3, Site No. 6, the Underground Waste Oil Storage Tank. This contamination is primarily represented by the chlorinated hydrocarbons (trans)1,2-dichlorethylene and trichloroethylene (TCE) in the 0.4 to 1.0 mg/l range, the solvent methyl ethyl ketone (MEK) at 0.043 mg/l, and fuel derivatives in the 0.04 to 0.70 mg/l range. Given the proximity of two Base production wells (33 and 34) to this site, these levels are considered to be of immediate concern.

9. On the basis of soil and groundwater results, two sites in Zone 4 appear to have environmental contamination present: Site 7, the Sludge Drying Beds, and Site 17, Drummed Water Storage Area No. 3 and the Waste Fuel and Solvent Sumps. MW-10, located directly south of Site 7, exhibited a somewhat elevated level of TCE (0.040 mg/l) and a high level of arsenic (0.35 mg/l). No significant levels of contamination were detected in the other three wells in Zone 4. Two boreholes drilled south of the Waste Fuel and Solvent Sumps in the Drummed Waste Storage Area (Site 17), however, exhibited elevated levels of soil contaminants, principally chloro- and dichlorobenzenes, in the range of from 1 to 100,000 ug/g. Given the proximity of the Base boundary in a downgradient direction, and the Gage Canal Company well field, these levels are considered to be of immediate concern. The potential for off-Base migration of contaminants from this site is very high.

10. On the basis of groundwater results for MW-14, there appears to be significant contamination

of groundwater in Zone 5, Site 14, Waste Pit No. 4, primarily with the volatile organic solvents TCE and MEK in the 0.012 to 0.230 mg/l range. Given the proximity of Base production well 33 to this site, these levels are considered to be of immediate concern.

11. On the basis of groundwater results in Zone 6, groundwater immediately downgradient from the AAVS/DAVA Evaporation Basins appears to be significantly contaminated with the breakdown products of organic volatile solvents (vinyl chloride and (trans) 1,2-dichloroethylene) in the 0.10 to 0.45 ug/l range. Relatively high values of specific conductance indicate that some contamination with inorganic salts not included in the Phase II Stage 1 analyses may also have occurred, most likely related to disposal of brines in these ponds. Given the proximity of Base well 35 to this Zone, observed contamination levels are considered to be of immediate concern.

12. On the basis of Base-wide Phase II groundwater results, there appears to be no widespread contamination with dissolved metals, although localized incidents of metals contamination were observed.

ES-5.0 RECOMMENDATIONS

The findings of the Phase II Confirmation Study, including GPR surveys, soil sampling, and ground-water sampling, at fifteen sites at Norton AFB indicate the need for follow-up IRP investigation at seven of these sites in five of the waste management zones. Routine monitoring of two additional sites, to be conducted by the Base separately from the IRP, is also recommended. The two sites ranked highest on the basis of their HARM scores in the Phase I Report do not have significant levels of environmental contamination associated with them.

The following section reviews both general and Zone-specific recommendations made for follow-up action.

ES-5.1 General Recommendations

Two general recommendations are made for actions to precede any further Zone-specific investigations:

1. Many of the findings and recommendations reported herein are based on a single round of groundwater samples. It is recommended that all twenty-two monitor wells be re-sampled in a second, verification round, that all the same parameters be analyzed for, and that the analysis results be compared to the first-round results before implementation of the Zone-specific recommendations.

2. All three of the active Base production wells (Nos. 33, 34, and 35) are located within 3,000 feet of at least one site recommended for further investigation. Wells No. 33 and 34 are located within 1,000 feet of Zone 3, the Underground Waste Oil Storage Tank. It is recommended that all three Base Production wells also be sampled during the second round of groundwater sampling, and that the samples be analyzed for field pH, specific conductance (SC), TOC, TOX, oil and grease and VOA at a minimum.

3. Surface geophysical surveys, including at least an electromagnetic conductivity (EM) survey, should be performed at all sites where additional monitor wells are recommended. Based on contrasts in electrical conductivity of ground water observed in Stage 1, it should be possible to track plumes of contamination downgradient from the sites to guide placement of additional monitor wells.

ES-5.2 Zone Specific Recommendations

Assuming that the findings reported based on the first round of sampling and analysis are verified by the second round, the following recommendations are made for follow-up investigation on a Zone-by-Zone basis.

ES-5.2.1 Zone 1 - Recommendations

Two sites in the Golf Course Waste Management Zone are recommended for further IRP investigation: Site 3, Waste Pit No. 2, Site 5, Fire Prevention Training Area No. 2. In addition a recommendation is made for Base monitoring of Site 4 (Waste Pit No. 1).

1. It is recommended that a magnetometer survey be performed at all sites where high-priority targets were identified in the GPR survey, in order to ascertain whether the targets identified are likely to be metallic (i.e. conductive) drums rather than rock boulders.

2. At Site 3, one additional monitor well should be installed adjacent to the site location as confirmed by the GPR Survey described herein. This well should be located directly northwest of the pit and screened in the shallow water-table aquifer at approximately the same depth as MW-3. The well should be surveyed and the water level measured and compared to the level in MW-3 to confirm the direction of the hydraulic gradient at the time of sampling. Both wells should be sampled concurrently for all parameters tested in Round 1, including dissolved metals.

   The rationales for installing a second well include the following: GPR results indicated a disturbed subsoil; specific conductance was high in MW-3; and the direction of shallow groundwater flow cannot be determined from the single existing monitor well. Unlike the other golf course sites, this site was paved over, and may still be generating leachate despite 24 years of burial.

3. At Site 5, a pair of monitor wells should be installed directly downgradient from the burn area in a west-southwesterly direction. The deep well should be screened below the silt zone at approximately the same depth as MW-9. The shallow well should be screened above the silt zone between 20 and 25 feet, and should include a sump, or blank pipe, extending 5 feet below the screen into the silt. The annular space around the sump should be adequately sealed to prevent downgradient migration through the silt. It is recommended that this well be drilled and sampled during the wet winter months. Parameters to be sampled in both wells and in MW-9 should include field pH, SC, oil and grease, TOC, TOX and VOA compounds plus xylene and MEK.

   The rationale for installing a new well cluster at this site is to monitor downgradient migration of contaminants in groundwater, whereas MW-9 monitors off-Base migration. The shallow well will monitor perched groundwater should it occur at least seasonally above the silt zone. A sumped well is considered preferable to a suction lysimeter for determination of VOA compounds, assuming that a saturated perched layer is encountered.

4. At Site 4, the Base should undertake a routine, infrequent water quality monitoring program for mon-

itor wells MW-1, MW-2 and MW-4. The analyte of concern is lead. The purpose of this monitoring is to detect any downgradient migration of lead which may occur in the future, but which is not documented by results to date. No further IRP actions are recommended for this site.

5. No further action is warranted at Sites 10 and 12.

ES-5.2.2 Zone 2 - Recommendations

At Site 2, Landfill No. 2, the Base should undertake a routine, semi-annual water quality monitoring program for monitor wells MW-11, MW-12, and MW-13. The analytes of concern are lead and VOA compounds. The purpose of this monitoring is to detect any migration of these compounds which may occur in the future, but which is not documented by results to date. No further IRP actions are recommended for this Zone.

ES5-2.3 Zone 3 - Recommendations

This Zone corresponds to Site 6, the Underground Waste Oil Storage Tank. The following actions are recommended:

1. Eight additional monitor wells should be installed, screened in the upper portion of the principal aquifer, with total screened depth increasing away from the site. It is recommended that two monitor wells be located on a northerly line connecting Site 6, the Underground Waste Oil Storage Tank, with Base production well 34, and two on a south-southwesterly line with Base production well 33. The other four additional monitor wells are to be placed along two lines radiating approximately down the direction of natural gradient, to the west and southwest. All nine wells should be sampled for field pH, SC, oil and grease, TOC, TOX, and VOA compounds plus xylene and MEK. The monitor well exhibiting the most degraded water quality is recommended for sampling and analysis of the complete list of U.S. EPA Priority Pollutants.

   The rationale for installing a network of monitoring wells around this site is to determine the magnitude and extent of confirmed groundwater contamination at this site, and the potential impact to human health, if any, related to the potential contamination of Base production wells.

2. A preliminary concept engineering study should be conducted to evaluate suitable remedial actions and options to obtain proper remediation and full closure of the site.

ES-5.2.4 Zone 4 - Recommendations

This Zone consists of the IWTP compound. Two sites are recommended for further investigation based on findings in this report: Site 7, the IWTP Sludge Drying Beds, and Site 17, the Drummed Waste Storage Area and Waste Fuel and Solvent Sumps (currently in the process of being closed). One factor strongly influencing recommendations made for this Zone is the presence of the Gage Canal Company well field just outside the Base boundary immediately to the south of Zone 4. Pumping in this well field is thought to influence the hydraulic gradient, at least in the principal aquifer. Additional monitor wells should be used to determine the gradient and direction of flow in both the shallow water-table and principal aquifer, as well as evaluate the presence or absence of contamination and its extent in groundwater.

1. All legally available information on the Gage Canal Company well field should be collected, including exact well locations, well construction details, lithologic logs, production rate and operating schedule and any records of sample analysis.

2. Four soil borings should be drilled through the Sludge Drying Beds (Site 7) to a depth of ten feet. They should be sampled continuously, and samples analyzed for oil and grease, metals, and VOA compounds plus MEK. This sampling program will serve to better define the contribution of contaminants to the subsurface from the unlined drying beds. Should Gage Canal Company records indicate that other contaminants are, or have been, detected in the well field, then this analytical list would be recommended for modification.

3. A total of four additional monitor wells should be installed in two clusters, one directly south of Site 17 (between that site and the Base boundary), and one off-Base on a direct line with the nearest active Gage Canal Company well. The shallow wells in the cluster should be screened, above the silt zone at depths comparable to MW-10 and MW-20 through MW-22. The deep wells should be screened below the silt zone, with total screened depth increasing away from the site.

The wells should be sampled for field pH, SC, oil and grease, TOC, TOX, and VOA compounds plus MEK and xylene. The monitor well having the most degraded water quality should be sampled for analysis of the complete list of U.S. EPA Priority Pollutants.

4. A preliminary concept engineering study should be conducted to evaluate suitable remedial actions and options to obtain proper closure of the site.

5. The Base should cease usage of the Waste Fuel and Solvent Sumps immediately, and ensure that all waste fuels and solvents are removed from the sumps.

6. No further evaluation of Site No. 13 or the IWTP Discharge Ditch is warranted.

ES-5.2.5 Zone 5 - Recommendations

Zone 5 corresponds to Site 14, Waste Pit No. 4, in the Civil Engineering compound (currently in the process of being closed).

1. Nine additional monitor wells should be installed in five clusters (including existing well MW-14), five in the shallow water-table zone to be equipped with sumps, and four in the principal aquifer. Total screened depths of the deep wells should increase away from the site. Two of the clusters should be on lines connecting the site with Base production wells 33 and 34, the remaining three radiating away from the site to the west and southwest in the direction of the natural gradient. The wells should be sampled for field pH, SC, TOC, TOX, and VOA compounds plus MEK. The monitor well exhibiting the most degraded water quality should be sampled for analysis of the complete list of U.S. EPA Priority Pollutants.

2. A preliminary concept engineering study should be conducted to evaluate suitable remedial actions and options to obtain proper closure of the site.

ES-5.2.6 Zone 6 - Recommendations

Zone 6 corresponds to Site 16, the AAVS/DAVA Evaporation Basins. These basins were reported to have received only water softening brines and thiosulfate wastes, although Phase II Stage 1 findings indicate they are also associated with groundwater contamination involving VOA compounds.

1. Three additional monitor wells should be installed and screened at a depth equivalent with the existing monitor wells (MW-16 through MW-19). They should be installed in a quarter circle to the west and southwest at a radius of 700 to 800 feet from the basins. One well should be located on a westerly line connecting the site with Base production well 35. The new wells should be sampled for field pH, SC, oil and grease, TOC, TOX, VOA compounds plus MEK, cyanide (to test for disposal in wet wells located immediately southwest of DAVA) and the inorganic anion thiosulfate. The well exhibiting the most degraded water quality should be sampled for analysis of the complete list of U.S. EPA Priority Pollutants.

2. A preliminary concept engineering study should be conducted to evaluate remedial actions and options to obtain proper rehabilitation or closure of the site.

ES-5.3 SUMMARY OF RECOMMENDATIONS

The recommendations described above have been summarized on a site-by-site basis in Table ES-1.

TABLE ES-1

SUMMARY OF RECOMMENDATIONS

Zone	Site	Recommendation	Rationale
(General)		Resample 22 existing monitor wells	Verify Stage 1 results
		Sample 3 Base production wells	Evaluate human health hazard via drinking water
1	3	Install 1 shallow monitor well adjacent to and northwest of confirmed site	Test for contamination in alternate downgradient direction
	4	Base initiate routine monitoring	Detection of contaminant migration
	5	Install 1 cluster of 1 shallow and 1 deep well directly west-southwest of burn area	Test for groundwater contamination in perched and principal aquifer
2	2	Base initiate routine monitoring	Detection of contaminant migration
3	6	Install 8 additional monitor wells	Magnitude and extent of contamination
	6	Concept Engineering Evaluation	Remedial action and its closure
4		Obtain all available information on Gage Canal Company wells	Evaluate human health hazard via drinking water
	7	Drill 4 soil borings through sludge drying beds	Test for soil contamination
	17	Install 2 well clusters including 1 well each in shallow water-table and principal aquifer	Magnitude and extent of contamination
	17	Concept Engineering Evaluation	Remedial action and site closure

TABLE ES-1 (cont.)

SUMMARY OF RECOMMENDATIONS

Zone	Site	Recommendation	Rationale
5	14	Install 1 shallow well and 4 clusters of 2 monitor wells each, including 1 each in shallow water-table and principal aquifer	Magnitude and extent of contamination
		Concept Engineering Evaluation	Remedial action and site closure
6	16	Install 3 additional monitor wells	Extent and magnitude of contamination
		Concept Engineering Evaluation	Remedial action and site closure

SECTION 1

INTRODUCTION

1.1 INSTALLATION RESTORATION PROGRAM

In 1976 the Department of Defense (DoD) devised a comprehensive Installation Restoration Program (IRP). The purpose of the IRP is to assess the potential migration and control the actual migration of environmental contamination that may have resulted from past operations and disposal practices on DoD facilities. In response to the Resource Conservation and Recovery Act of 1976 (RCRA) and in anticipation of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA, or "Superfund"), the DoD issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM) dated June, 1980 (DEQPPM 80-6), requiring identification of past hazardous waste disposal sites on DoD agency installations. The U.S. Air Force implemented DEQPPM 80-6 by message in December, 1980. The program was revised by DEQPPM 81-5 (11 December 1981) which reissued and amplified all previous directives and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 by message on 21 January 1982. The Installation Restoration Program has been developed as a four-phase program as follows:

- Phase I - Problem Identification/Records Search
- Phase II - Problem Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Corrective Action

Only the Phase II, Stage 1, Problem Confirmation portion of the IRP effort at Norton Air Force Base was included in the effort described in this Report. Definitions of the terms and acronyms used in this report are in Appendix A.

1.2 PROGRAM HISTORY AT NORTON AIR FORCE BASE

Roy F. Weston, Inc. (WESTON) has been retained by the United States Air Force Occupational and Environmental Health Laboratory (OEHL) under Contract Number F33165-80-D-4006, to provide general engineering, hydrogeological and analytical services. The Phase I Problem Identification/Records Search for Norton Air Force Base (NoAFB) was accomplished by Engineering Sciences, Inc. (ESI) in June 1982, and their Final Report was dated October 1982. In response to the

findings contained in the ESI Phase I Final Report, the OEHL issued Task Order 0017 to WESTON, directing that a Pre-Survey be conducted at NoAFB. The purpose of this pre-survey was to obtain sufficient information to develop a work scope and cost estimate for the conduct of a full Phase II, Stage 1, Problem Confirmation Study at NoAFB.

The pre-survey site inspection was conducted at NoAFB by two WESTON personnel and a representative of OEHL on 26 April 1983. The pre-survey report was submitted in May 1983. Following modifications in the scope of work, Task Order 0021 (dated 2 April 1984) was issued, authorizing a Phase II, Stage 1, Problem Confirmation Study for fourteen (14) sites in six (6) waste management zones. A copy of the formal Task Order authorizing this work is included in this Report as Appendix B.

The first phase of field work, including drilling and sampling of 12 soil borings and installation of 15 monitor wells was performed between 3 November and 12 December 1983. Seven additional wells were installed between 17 May and 31 May 1984. Surveying and sampling were performed from 5 to 13 July and 30 to 31 July 1984.

1.3 BASE PROFILE

Norton Air Force Base (NoAFB), assigned to the Military Airlift Command (MAC), occupies 2,003 acres of contiguous property in southern California, adjacent to and southeast of the city of San Bernardino. Figure 1-1 is an index map showing the location of NoAFB. The Base occupies a portion of a low-lying alluvial plain which is bounded on the northeast by the San Bernardino Mountains and on the northwest by the San Gabriel mountains. The Santa Ana River Wash forms the southern boundary of the Base. Land use to the north, west, and south of the Base is dominated by residential and commercial activities in the San Bernardino suburbs, while to the east more rural conditions exist.

Norton Air Force Base was activated on 1 March 1942 as the San Bernardino Air Depot, functioning as an Air Logistics Center (ALC). The first overhaul center for aircraft jet engines in the U.S. Air Force was activated at this location. In a program known as Project "I", Air Force, Navy and industry jet engine specialists were trained in jet engine maintenance. During World War II, the Base served as a repair center for various aircraft. At the termination of the war, Norton's responsibilities included maintenance of

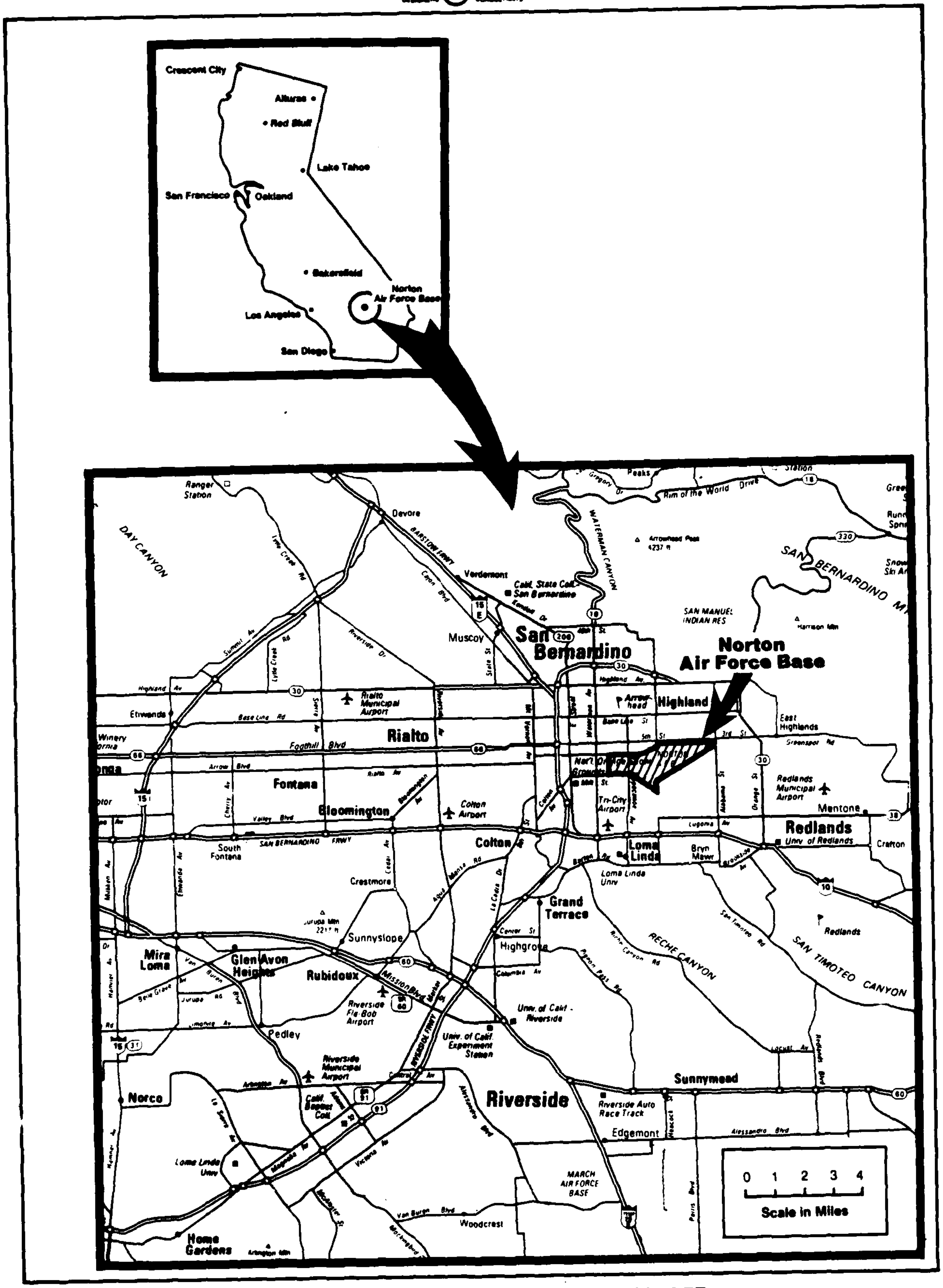


FIGURE 1-1 INDEX MAP FOR NORTON AFB

several cargo and fighter aircraft as well as jet engine overhaul work for the Air Force Logistics Command (AFLC). The San Bernardino Air Material Area (SBAMA) had the responsibilities for providing maintenance and logistics for all liquid fuel intercontinental ballistic missiles and space booster systems in the Air Force inventory. Norton AFB maintains storage facilities for the Atlas, Thor and Titan II missiles. and has recently been assigned the management of the MX Missile Program.

In June 1966, SBAMA was phased out and in its place came the 63rd Military Airlift Wing (MAW). After functioning primarily as a supply depot for almost a quarter of a century, NoAFB became a Military Airlift Command (MAC) Base with a flying mission. The arrival of the 63rd MAW required additional jet fuel facilities to support the C-141 aircraft. Norton has become one of three aerial ports of embarkation for MAC on the West Coast and has been involved extensively in providing airlift support for the entire Pacific Theater of Operations. In the spring of 1972, the 944th Military Airlift Group (MAG) was added to the Wing.

In 1968, the Headquarters for the Aerospace Audiovisual Service (AAVS) moved to NoAFB. AAVS was established to provide the audiovisual services and products to meet Air Force requirements. In 1980, the Headquarters for the Defense Audiovisual Agency (DAVA) was located in the same facility as AAVS. The mission of DAVA has been to provide similar audiovisual services as AAVS to all Department of Defense agencies.

The present host command at Norton AFB is the 63rd Military Airlift Wing, whose primary mission is to maintain immediate airlift capability to deliver and sustain air and ground combat forces anywhere in the world. The Wing also provides airlift augmentation as may be directed to Air Force components, exercises, and training programs to maintain a high state of readiness of all Wing resources and assigned reserve forces. The Wing provides the support functions to maintain NoAFB facilities, as well as hosting 32 tenant activities.

Past Air Force activities at NoAFB in support of assigned missions have resulted in the occurrence on the Base of several waste disposal sites of potential concern. Each of these sites was rated by ESI (1982) during Phase I activities in accordance with the IRP Hazard Assessment Rating Methodology (HARM). The results of these ratings are

summarized in Table 1-1 (from the ESI report). Based upon these ratings and all other pertinent data, ESI recommended that Phase II activities concentrate on the sites numbered 1 through 12 in Table 1-1. Figure 1-2 shows the locations of all the rated sites.

From the Phase II Pre-Survey Report and further discussions with the Air Force, 14 of the rated sites and one additional site (not rated in the Phase I Report) were found to require problem confirmation studies. Eleven of these sites were organized into three management zones, while the other three were treated as separate zones. The following is a list of the sites evaluated during the Phase II study (locations are shown in Figure 1-3):

- Zone 1 - Golf Course Waste Management Zone, including:

  Site 1, Industrial Waste Lagoons
  Site 3, Waste Pit No. 2
  Site 4, Waste Pit No. 1
  Site 5, Fire Protection Training Area No. 2
  Site 10, Landfill No. 1
  Site 12, Waste Pit No. 3

- Zone 2 - Landfill Waste Management Zone, including:

  Site 2, Landfill No. 2
  Site 11, Fuel Sludge Disposal Area

- Zone 3

  Site 6, Underground Waste Oil Storage Tank

- Zone 4 - Industrial Waste Treatment Plant Waste Management Zone, including:

  Site 7, IWTP Sludge Drying Beds
  Site 13, IWTP Sludge Disposal Area
  Site 17, Drummed Waste Storage Area No. 3 and Waste Fuel and Solvent Sumps
  IWTP Discharge Ditch (not rated)

- Zone 5

  Site 14, Waste Pit No. 4

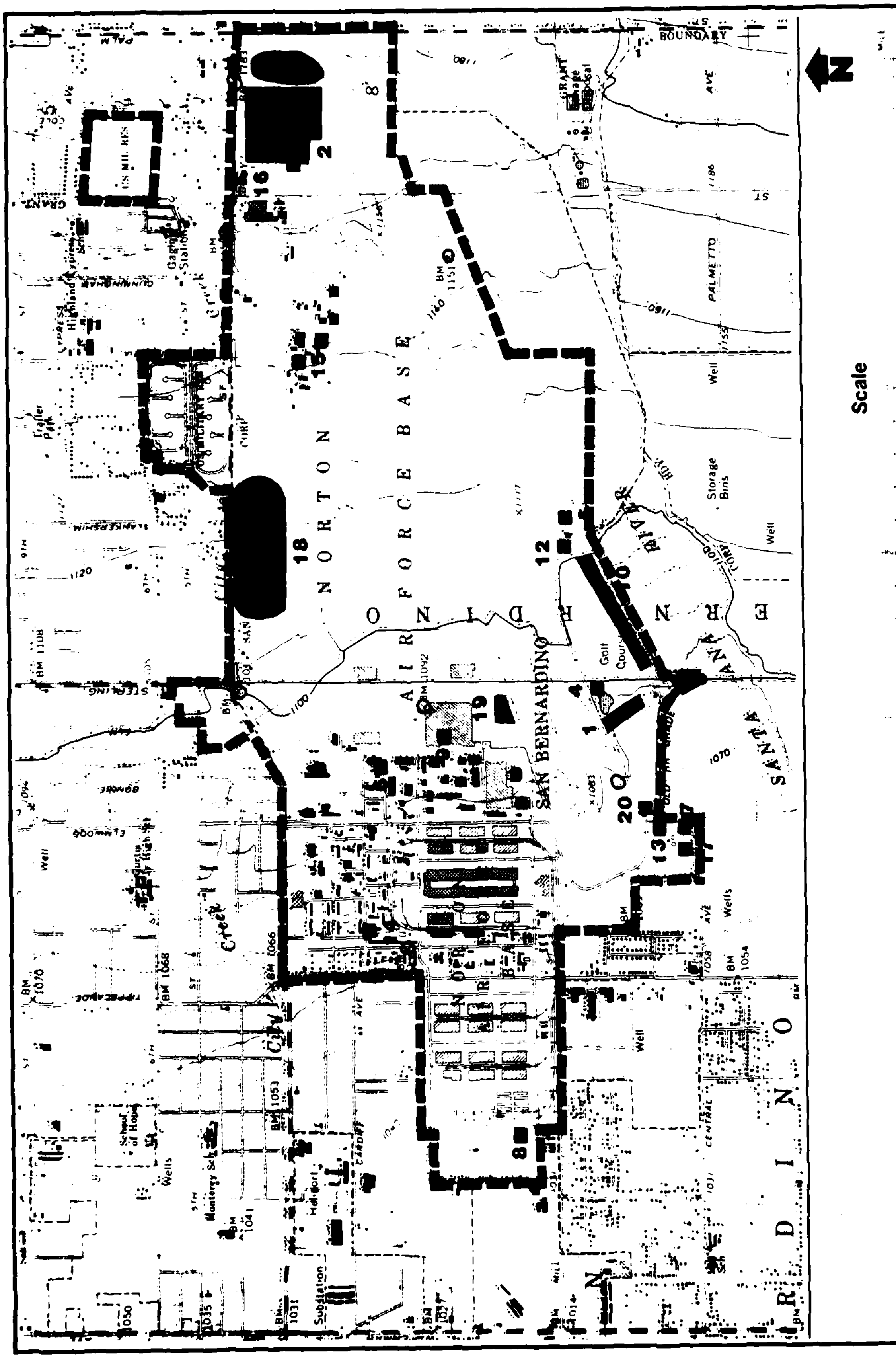
TABLE 1-1

PRIORITY RANKING OF POTENTIAL CONTAMINATION SOURCES

NORTON AFB

(From the Phase I Report)

Site Number by Rank	Site Name	Date of Operation or Occurrence	Overall Total Score
1	Industrial Waste Lagoons	1950 - 1960	74
2	Landfill No. 2	1958 - 1980	66
3	Waste Pit No. 2	1957 - 1958	65
4	Waste Pit No. 1	Mid 1950's	64
5	Fire Protection Training Area No. 2	1962 - 1982	62
6	Underground Waste Oil Storage Tank	1948 - 1981	59
7	IWTP Sludge Drying Beds	1957 - Present	58
8	PCB Storage and Spill Site	1982	56
9	Chemical Spill Area No. 5	1940's - 1982	56
10	Landfill No. 1	1943 - 1958	56
11	Fuel Sludge Disposal Area	1957 - 1977	55
12	Waste Pit No. 3	Late 1950's	55
13	IWTP Sludge Disposal Area	1957 - 1966	53
14	Waste Pit No. 4	1940's - Present	53
15	Oil Spill Areas	1965 - 1975/1975 - 1982	52
16	AAVS/DAVA Evaporation Basins	1968 - 1980	51
17	Waste Drum Storage No. 3	1961 - Present	50
18	Avgas Spill Area	1950 - 1965	49
19	Waste Drum Storage No. 1	1943 - 1960	48
20	Low Level Rad. Waste Burial	1950's	47



Source: ESI (1982)

Note: Site Identifications Corresponding to Numbered Sites Provided in Table 1-1

FIGURE 1-2 LOCATION OF POTENTIAL SOURCES OF CONTAMINATION IDENTIFIED IN PHASE I

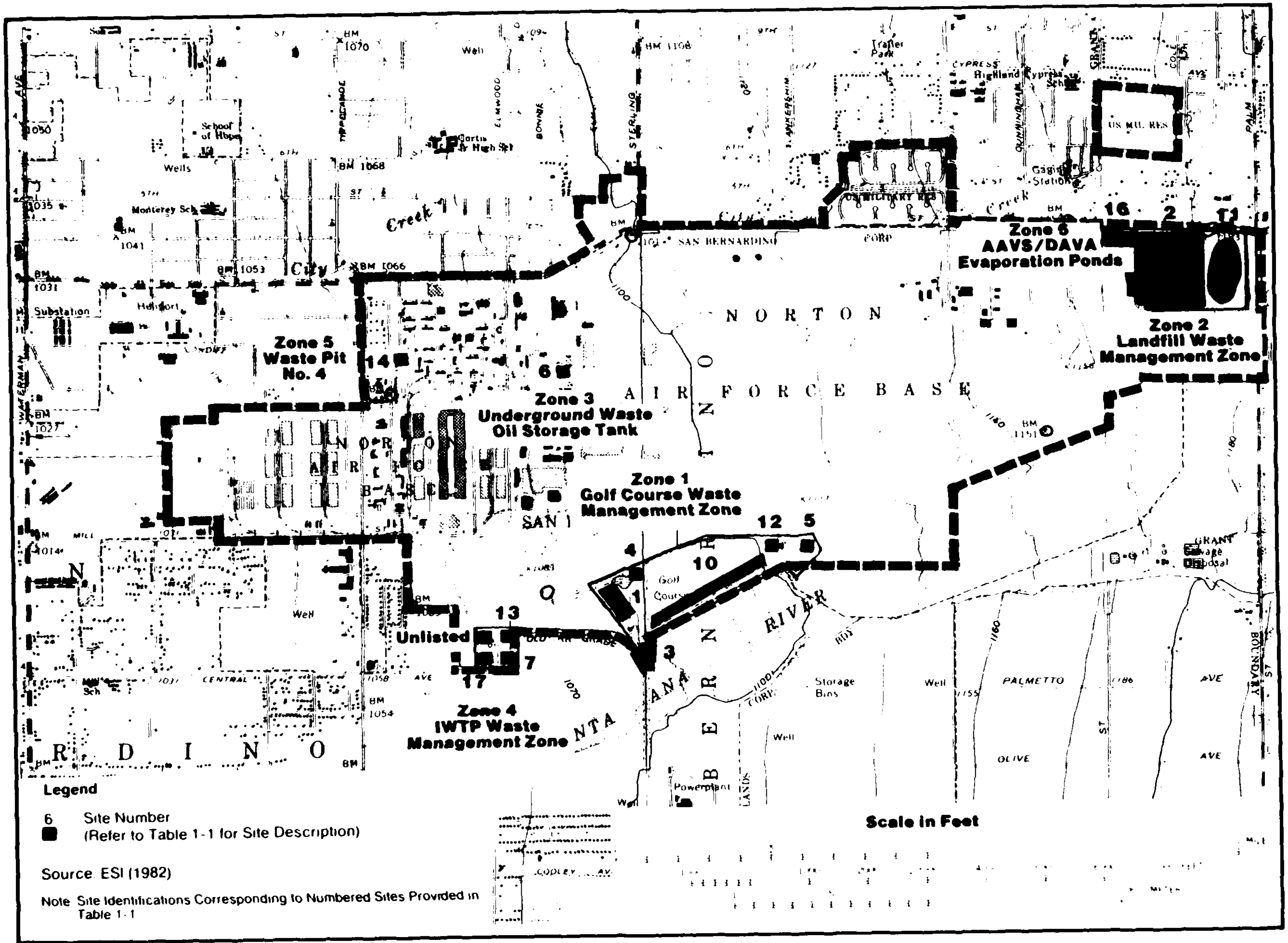


FIGURE 1-3 LOCATION OF PHASE II INVESTIGATION SITES AT NORTON AFB

- Zone 6

  Site 16, AAVS/DAVA Evaporation Basins

The text below provides a brief history and description of each Zone.

1.3.1 History and Description of the Golf Course Waste Management Zone

Six of the twelve highest ranked sites, including a landfill, a series of industrial waste lagoons, three waste pits, and a Fire Protection Training Area (Table 1-1) are present on or near the NoAFB Golf Course, as shown in Figure 1-4. The six sites were treated as a single waste management zone for groundwater monitoring purposes, although specific actions were taken at individual sites within the zone.

The Golf Course Waste Management Zone (GCWMZ) is located between the South Perimeter Road and the southern Base boundary, running from Golf Course Drive eastward to the point where the South Perimeter Road nearly meets the boundary corner. It includes, from west to east, a portion of the Golf Course, the pistol range, and a Fire Protection Training Area (No. 2).

1.3.1.1 Site No. 1, Industrial Waste Lagoons

Prior to completion of the industrial wastewater treatment plant in 1959, many wastes generated at the industrial facilities on Base were piped to a series of lagoons located along the corner of Golf Course Drive and Perimeter Road. The lagoons were utilized between 1950 and 1960. Wastes reportedly discharged into the lagoons included: chromates, organic solvents, phenols and miscellaneous waste oils. Phenolic odors were typically noticeable in the area when the lagoons were active. At times, floating organic compounds on the water surface were burned off.

The initial configuration of the lagoons involved approximately nine individual pond cells grouped into several series. Depth of the lagoons was approximately three feet. The general procedure was to allow the liquid

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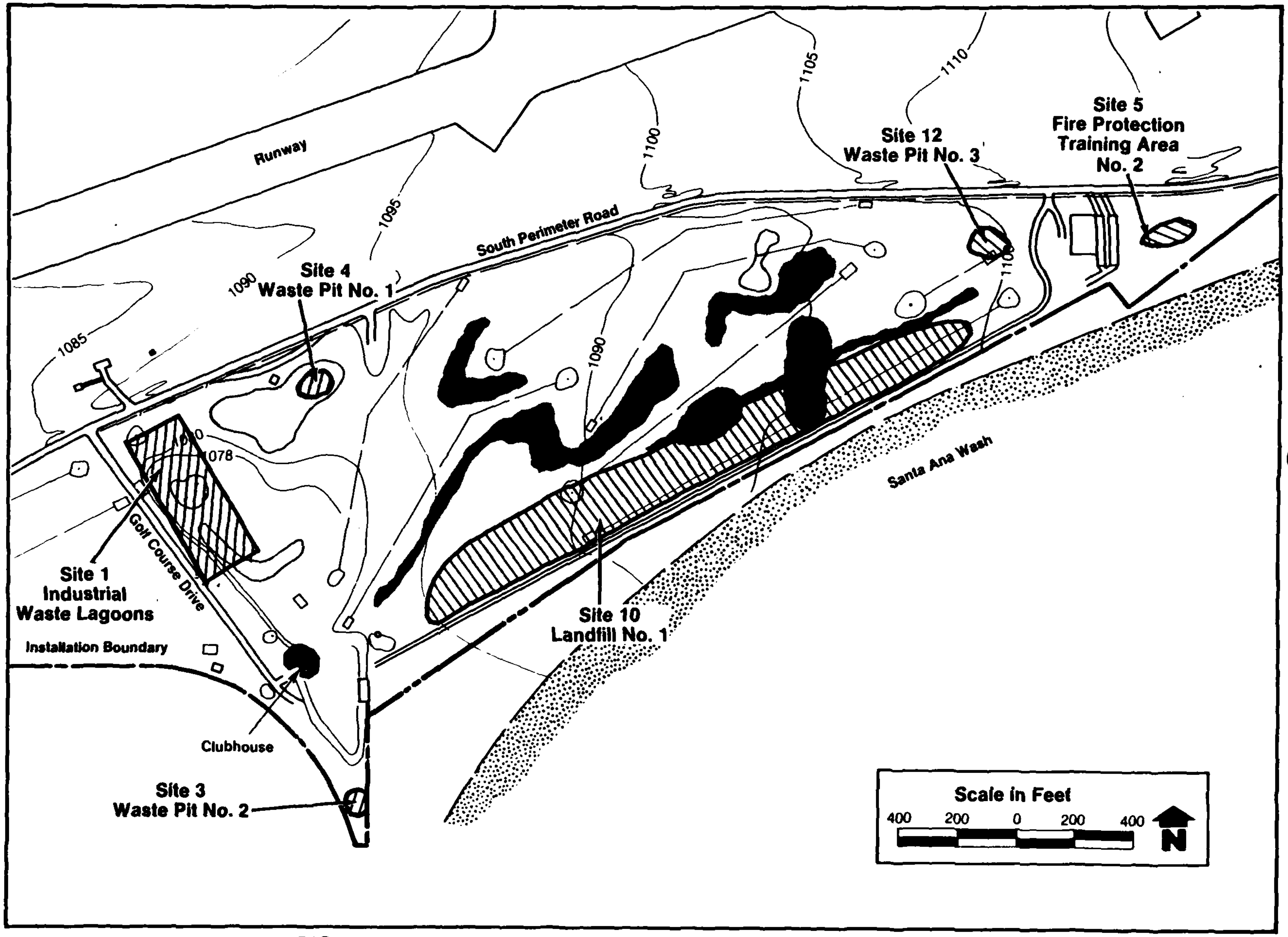

FIGURE 1-4 GENERAL SITE MAP FOR ZONE 1, THE GOLF COURSE WASTE MANAGEMENT ZONE

phase of the waste to percolate into the soil. Between 1957 and 1958, the lagoons were reconstructed and arranged in a new configuration. Two rows of rectangular lagoons were established with a series of five to six individual cells separated by earthen dikes. The old lagoons had been dredged to increase percolation rates and the dredged spoils were disposed in waste pit No. 2. In 1960, the lagoons were covered and regraded and the area was developed into part of the Base golf course. Two of the golf course ponds (Ponds 2 and 3) are presently situated in the general location of the waste lagoons.

1.3.1.2 <u>Site No. 3, Waste Pit No. 2</u>

This site is located on the southern boundary beneath the area now used as the clubhouse parking lot. This area is in the floodplain of the Santa Ana River and therefore is subject to occasional flooding and potential erosion. This site was used as a waste pit in 1957 and 1958. The pit was very deep and was used for disposal of miscellaneous wastes, such as metal, waste oils, grease from mess hall grease traps, and sludge dredged from the industrial lagoons. The sludges may have contained organic compounds and heavy metal residues.

1.3.1.3 <u>Site No. 4, Waste Pit No. 1</u>

Waste Pit No. 1 is located in the area of the Golf Course, just south of South Perimeter Road, beneath the site now occupied by the Golf Course irrigation pond (Pond 1). It was operated as a waste pit from 1955 to 1956. Interviews with personnel involved in the operation of the pit indicated that drums of waste had been disposed of in the pit. They also indicated that materials in the pit were occasionally burned.

1.3.1.4 <u>Site No. 5, Fire Protection Training Area No. 2</u>

Fire Protection Training Area No. 2, located on the south side of the main runway directly east of the pistol range, has been in use since the late 1950's. Waste fuel, waste oil, and some combustible waste chemicals (i.e. spent

solvents) were used during training exercises until 1972; after 1972 only uncontaminated JP-4 and JP-5 were burned. Some waste chemicals (i.e. waste oils) may have been used in the area on occasion. The fire training area is comprised of a pit surrounded by a two-foot earthen berm. The procedures for conducting a training exercise involve wetting the surface of the pit with water to allow the fuel to float; then repeatedly igniting the fuel and extinguishing the fire. Extinguishing agents have included water, protein, and AFFF (Air Force Firefighting Foam). The frequency of training exercises has varied considerably over the years. During the early 1970's exercises may have been conducted four to five times per week. In the more recent years, exercises have been conducted on a monthly basis. Approximately 500 to 1000 gallons of fuel are used per exercise. The pit is unlined and has no drainage collection system. All residual liquids are allowed to evaporate or percolate into the ground.

1.3.1.5 Site No. 10, Landfill No. 1

Landfill No. 1 was located along the Santa Ana River Wash on the south boundary of NoAFB in a narrow strip running between the current golf course clubhouse and the pistol range (Figure 1-4). This area was once part of the River wash and is subject to occasional flooding. Precise dimensions of the landfill were uncertain; however, it has been estimated that the landfill occupied 15 acres. The landfill was operated between 1943 and 1958 strictly as an area fill; no trenches were dug below grade. Based on the general topography of the area, it has been estimated that the fill material did not exceed 20 feet in depth. There have been reports that routine burning was practiced. The wastes disposed of in the landfill were primarily general refuse but it is possible that small amounts of industrial wastes may also have been disposed of in this landfill. There was no confirmation in Phase I of any drum disposal within the landfill. However, golf course personnel have reported localized areas of subsidence and patches of ground which will not support vegetation.

1.3.1.6 Site No. 12, Waste Pit No. 3

Waste Pit No. 3 was located west of the current pistol range beneath the golf course, and was approximately 10 to 15 feet deep. It was used around 1958. Chemical wastes as well as other miscellaneous wastes, such as waste lumber, were taken to the pit and burned. Some drums of chemical wastes may have been buried in this area.

1.3.2 History and Description of the Landfill Waste Management Zone

This zone includes two of the twelve highest ranking sites in Table 1-1, Landfill No. 2 and the Fuel Sludge Disposal Area. They are located next to each other in the northeast sector of the installation, and occupy a combined area of about 50 acres (Figure 1-5). They have been grouped into a single waste management zone for the purpose of groundwater monitoring.

1.3.2.1 Site No. 2, Landfill No. 2

Landfill No. 2 is located directly east and southeast of AAVS/DAVA headquarters in the northeast corner of the installation. It is bounded to the southwest by Perimeter Road. It is a square-shaped area occupying approximately 31 acres. Landfill operations entailed trench and fill procedures with daily cover. The trenches were 300 to 400 yards long, 25 feet wide and 20 to 40 feet deep. Most of the trenches had a north-south orientation. No burning of wastes was conducted at the landfill. The site was utilized for waste disposal from 1958 to 1980, and has since been closed and covered with soil. Very little vegetation has been established over the fill area. Some piles of hardfill material have been placed on a corner section of the landfill surface. The landfill was primarily used to dispose of general refuse and smaller quantities of industrial waste. These industrial wastes were reported to have included spent solvents (i.e. TCE, carbon tetrachloride), refrigerants, acids, paint strippers, paints and thinners, waste oils, and sludge from the industrial

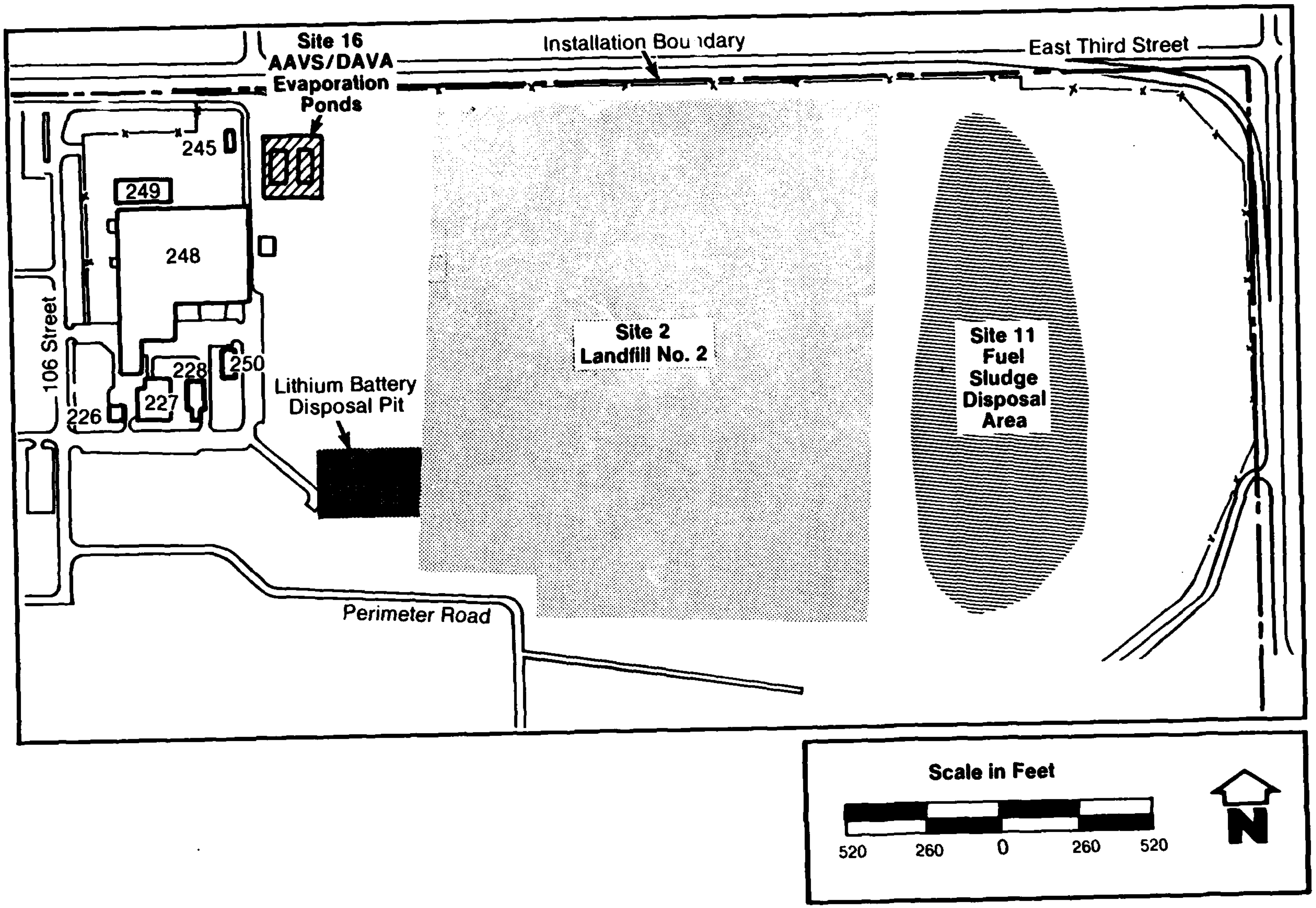

FIGURE 1-5 GENERAL SITE MAP FOR ZONE 2, THE LANDFILL WASTE MANAGEMENT ZONE, AND ZONE 6, THE AAVS/DAVA EVAPORATION PONDS

wastewater treatment plant (IWTP) drying beds. In addition, approximately 100 lithium batteries were buried in a pit 40 to 50 feet deep at the southwest corner of the landfill.

1.3.2.2 Site No. 11, Fuel Sludge Disposal Area

The fuel sludge disposal area is located directly east of Landfill No. 2, occupying an area of approximately 18 acres. From 1958 to the mid-1970's, this area was used for surface spreading of fuel sludges generated from the cleaning of Aviation Gasoline (AVGAS) and JP-4 storage tanks in the POL area. The AVGAS sludges, generated during the early portion of the period, contained tetraethyl lead. Occasionally, greases from grease traps throughout the Base were disposed of in this area.

1.3.3 History and Development of Site No. 6, Underground Waste Oil Storage Tank

This is the site of a 10,000 gallon underground waste oil storage tank located next to Building 647. Building 647 has since been demolished and the area has undergone conversion for expansion of the Base Exchange Service Station. Figure 1-6 is a general site map of the area. The tank was used from 1948 to 1981 for the temporary storage of waste petroleum products. These petroleum products included waste fuels, oils, hydraulic fluid, PD-680 and other spent cleaning solvents. In 1981, a leak test of the tank was conducted. The test entailed measuring the tank volume, locking the tank for 48-hours, then remeasuring and comparing the tank volumes (compensating for temperature changes). The results indicated that some loss of product was occurring. The contents of the tank were transferred to another storage tank. It is not known how long this leak may have occurred or what quantity of waste oils may have leaked from the tank. It is presently not known whether the tank has been removed or repaired for further service.

1.3.4 History and Development of the IWTP Waste Management Zone

The Industrial Waste Treatment Plant (IWTP) is located on the southern boundary of the Base, just south of the western end of the main runway and adjacent to the golf course. The Plant, completed in 1960, was built to treat liquid wastes generated from aircraft maintenance and washing, electroplating, stripping, painting and cleaning. Wastes are transported to the IWTP by industrial sewers and by

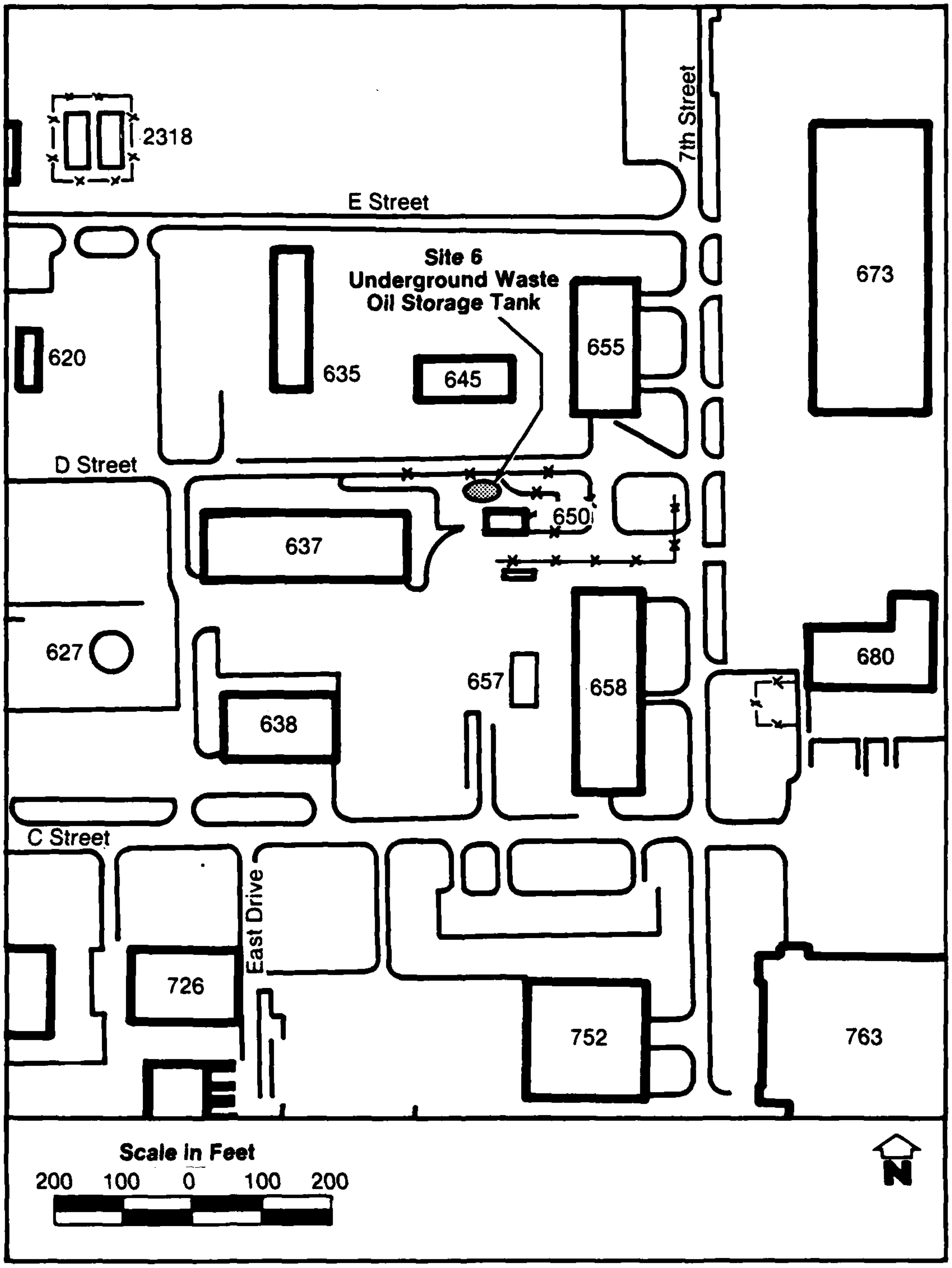

FIGURE 1-6 GENERAL SITE MAP FOR ZONE 3, THE UNDERGROUND WASTE OIL STORAGE TANK

truck. Plant discharge occurs through an unlined ditch to the Santa Ana Wash, at rates varying from a low of 80,000 gallons per day (gpd) in summer to a high of 200,000 gpd in winter. Sludge from the plant is dried in a series of 12 unlined beds occupying a total area of 17,280 square feet directly southeast of the plant. Historically, the dried sludge (approximately 100 cubic yards per year) has been either hauled to disposal areas on Base property or disposed of off-Base by a private contractor.

Three rated sites and one unranked site are located in the immediate vicinity of the IWTP as shown on Figure 1-7: Site No. 7, the IWTP Sludge Drying Beds; Site No. 13, the IWTP Sludge Disposal Area; Site No. 17, Drummed Waste Storage Area No. 3 and the Waste Fuel and Solvent Sumps; and the unlined discharge ditch. A fourth site lies adjacent to this zone (Site No. 20, Low-Level Radiation Waste Site). but this site was not evaluated during Phase II, Stage 1. Two of the sites are within the fenced compound including the IWTP and golf course maintenance facilities. The IWTP Sludge Disposal Area is just outside the fence to the north. The unlined IWTP discharge ditch, which was observed during the Pre-Survey visit to contain foaming surfactants, is located to the west of and outside the compound. Five commercially-owned groundwater production wells (Gage Canal Company) are located less than 200 yards southwest of the IWTP near the Base boundary. For groundwater monitoring purposes, the three ranked sites and the one unranked site have been grouped into a single waste management zone.

1.3.4.1 Site No. 7, IWTP Sludge Drying Beds

The sludge drying beds, located approximately 300 feet southeast of the IWTP, are unlined and uncovered and, thus, are subject to leaching and percolation of the leachate into the subsurface. A one-time analytical test on the sludge in seven drying beds yielded concentrations of lead from <0.005 to 2.94 mg/L (ESI, 1982), although there was no indication which type of extraction (total, EP toxicity, other) was used in this test.

1.3.4.2 Site No. 13, IWTP Sludge Disposal Area

This site, located just north of the IWTP fence, was used as a ground fill area for IWTP dried sludge sometime between 1957 and 1966. The area is less than 200 feet square, and the fill probably less than 5 feet thick.

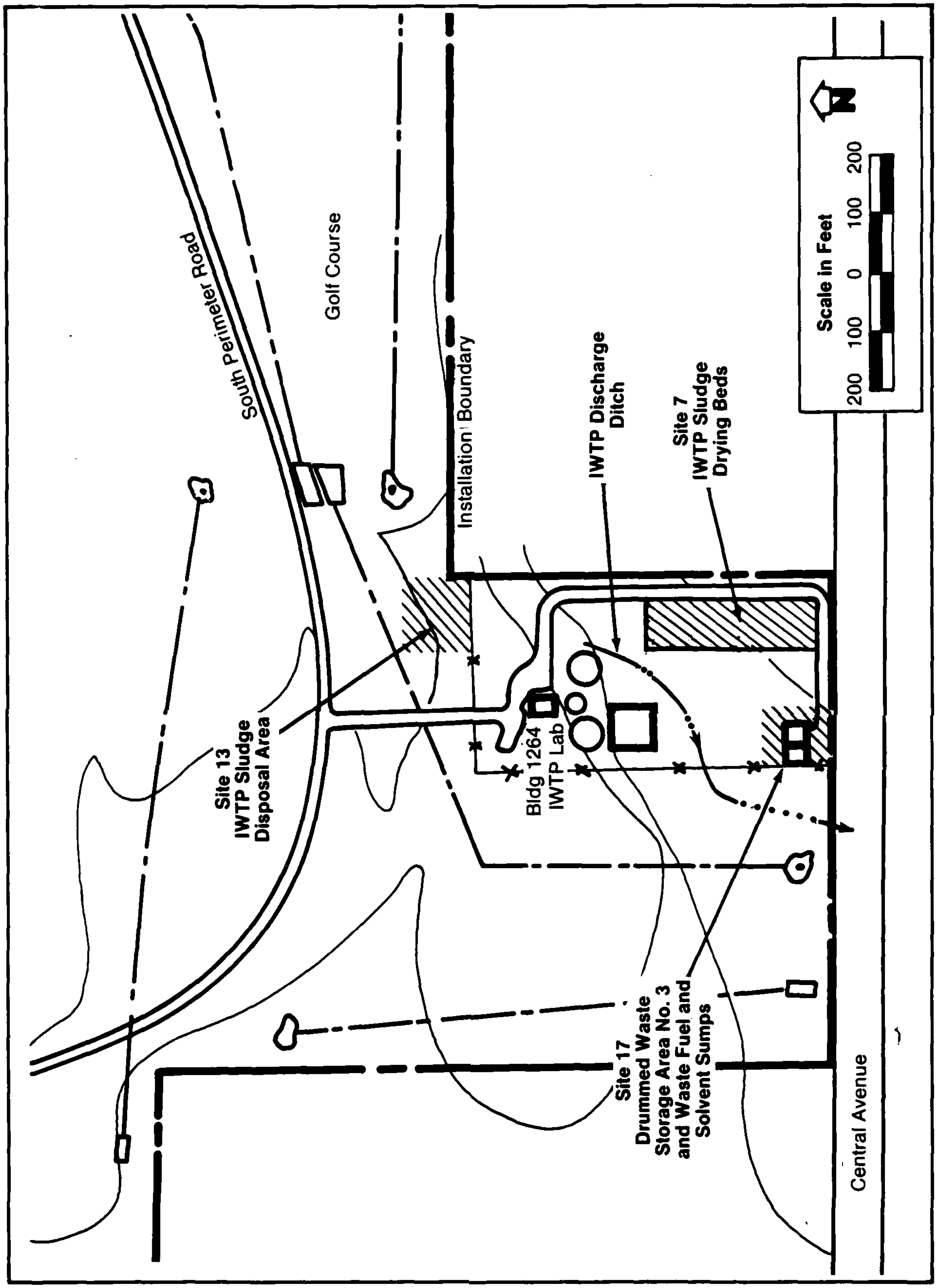

FIGURE 1-7 GENERAL SITE MAP FOR ZONE 4, THE IWTP WASTE MANAGEMENT ZONE

1.3.4.3 Site No. 17, Drummed Waste Storage Area No. 3 and Waste Fuel and Solvent Sumps

This site, located in the southwest corner of the IWTP compound, consists of two cement, brick-lined holding cells. These cells were originally intended as burn cells for chemical wastes, but could not be used as such after enactment of State Air Quality Regulations in 1961. Since that time, drummed wastes have been stored on pallets in the area immediately adjacent to the cells on the north, east and south sides. Phase I interviews with IWTP personnel indicated that occasional leaks and spills have occurred from drums in this area. In addition, the two cells were converted into holding lagoons or sumps for skimmings from the IWTP treatment processes and for bulk waste fuels brought in from other areas of the Base. This usage is on-going. The walls of the eastern cell are approximately 3 feet high. The eastern cell drains from a bottom valve into the western cell, which is approximately one foot deep, with walls finished at ground level. The eastern cell functions as an oil/water separator; the western cell as an evaporation/percolation lagoon for waste water drained from the bottom of the eastern cell. The Drummed Waste Storage Area (No. 3) and the waste fuel and solvent sumps have been treated as a single site because contaminants potentially discharged to the subsurface from the two areas could not be sampled separately.

1.3.4.4 IWTP Discharge Ditch

This unlined ditch runs south across the western portion of the IWTP Waste Management Area in a culvert across part of the Golf Course and discharges to the Santa Ana Wash. It carries the discharge from the IWTP and may have resulted in the percolation of only partially treated effluent at times of temporary IWTP failure.

1.3.5 History and Development of Site No. 14, Waste Pit No. 4

Waste Pit No. 4 is located in the industrial part of the installation, at the north end of Building 412, as shown in Figure 1-8. It actually encompasses the site of two 10-foot diameter, 10-foot deep pits. The northerly pit has been backfilled with loose dirt and gravel. The pits were used from the 1940's to the 1960's for the disposal of waste paints and thinners generated at the Civil Engineering Paint Shop. From 1960 to the present, the pits have been used for the disposal of diluted paint wash water (approximately two

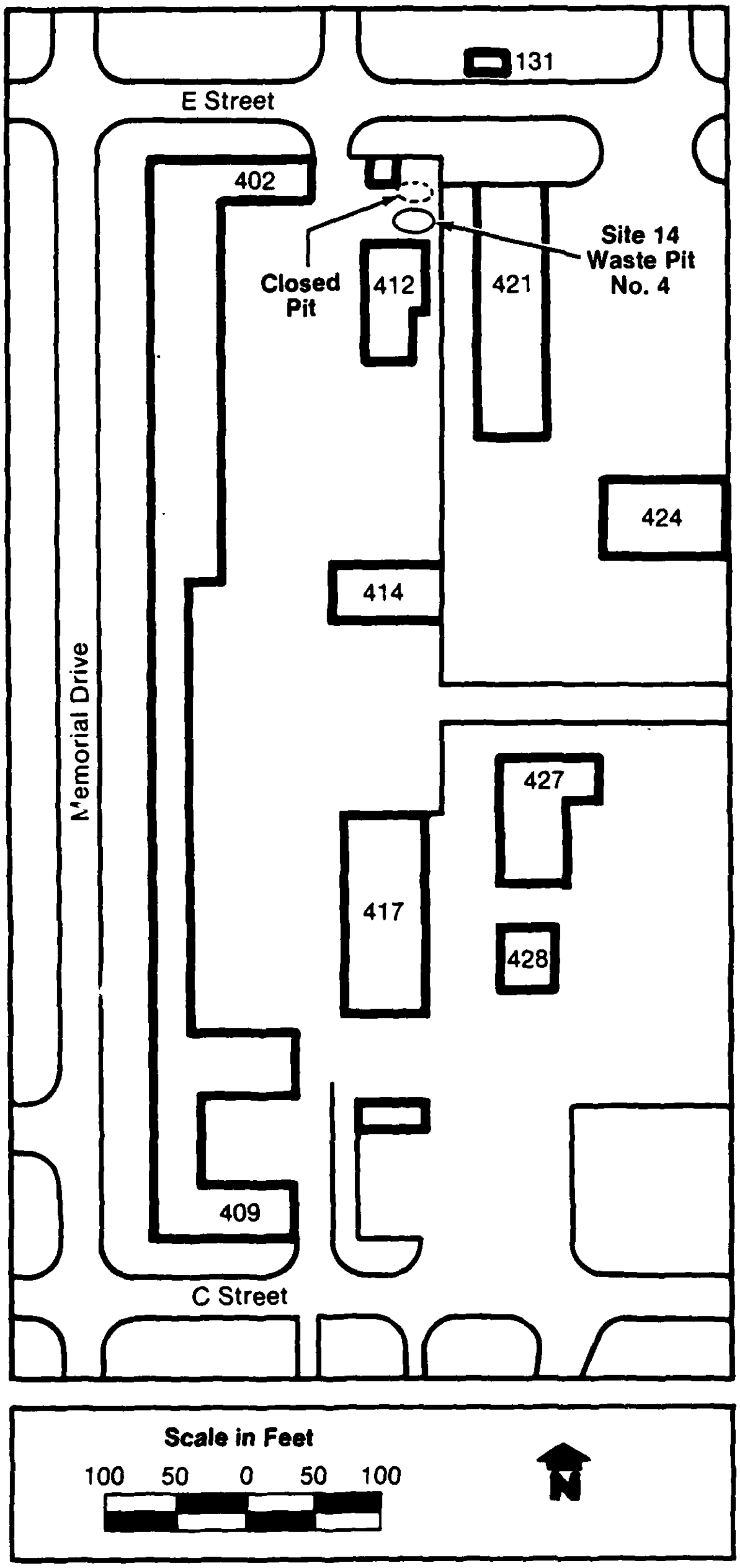

FIGURE 1-8 GENERAL SITE MAP FOR ZONE 5, WASTE PIT NO. 4

gallons per month). The southerly pit is still open and the presence of organic solvents in the pit is strongly indicated. Base Production Well No. 33 is one block away to the southeast, and could become contaminated by solvents moviung through the ground water flow system.

1.3.6 History and Description of Site No. 16, The AAVS/DAVA Evaporation Basins

This site is located adjacent to the north boundary of the installation, near the eastern end, immediately northeast of the AAVS/DAVA headquarters building, as shown in Figure 1-5. At the time the AAVS facility was established in 1968, two evaporation basins having a capacity of 65,000 gallons each were built as part of the waste treatment system. One basin received water softening brines at a rate of approximately 150,000 gallons per year; the other received thiosulfate photographic solutions at a rate of about 15,000 gallons per year. The basins were originally lined with asphalt. In 1981, they were relined with a bituminous coating after it was discovered that waste solutions had been leaking into the ground through the basin bottoms.

1.4 CONTAMINATION PROFILE

From 1942 to 1966, NoAFB functioned as an Air Logistics Center (ALC) and as such hosted extensive industrial activities related to jet engine overhaul and general aircraft maintenance. Wastes generated from these activities included acid plating solutions, caustic solutions, cyanide solutions, metal wastes, paint solutions, phenolic paint thinners and strippers, and solvents such as PD-680, toluene, methyl ethyl ketone (MEK) and trichloroethylene (TCE). Dilute stream solutions were discharged to an industrial waste sewer system and carried to storm ditches until 1950, to percolation lagoons in the area of Ponds 2 and 3 on the present golf course from 1950 to 1960, and treated at the IWTP from 1960 until the present. Concentrated wastes were generally stored in 55 gallon drums and removed by private contractor, although some on-Base disposal has been documented in the Phase I report (Landfill No. 2, Waste Pits Nos. 1 through 4). The rate of waste generation diminished after 1966, but the types of industrial wastes produced remained essentially the same. Operation of the AAVS/DAVA facilities in Building 248 since 1968 has resulted in the generation of photographic wastes. On-Base disposal of brines and thiosulfate wastes has occurred through the use of evaporation ponds adjacent to the building. In addition, significant quantities of waste fuels, oils, hydraulic fluids, fuel sludges and some

solvents have been generated by shop and flightline activities and POL operations. Contamination from these petroleum wastes is likely to have occurred in the vicinity of the underground 10,000 gallon waste oil storage tank, Fire Protection Training Area No. 2, the Fuel Sludge Disposal Area, and various other storage and spill sites on Base.

Based on the Phase I Records Search Report (ESI, 1982), key chemical parameters of potential concern at NoAFB are: volatile organic compounds (VOA) including MEK, phenols, oil and grease, and select metals. In addition, total organic carbon (TOC) and total halogenated hydrocarbons (TOX) are of interest as indicator parameters for potential contamination from organic compounds. To develop an initial determination of whether or not past operational and disposal practices have adversely impacted the environment, samples of soils, surface water, and groundwater were collected in and around 15 sites grouped into 6 study areas, or Waste Management Zones. The parameters analyzed for each site are listed by Zone in Table 1-2. The list of thirty-two USEPA Priority Pollutant volatile organic compounds included in the standard VOA analyses (USEPA Methods 601 and 602) is given in Table 1-3, along with detection limits for each compound in water and sediment. Details of the sampling program and other field work accomplished by WESTON at NoAFB are provided in section 3 of this report.

1.5 PROJECT TEAM

The Phase II, Stage 1, Problem Confirmation Study at NoAFB was conducted by staff personnel of Roy F. Weston, Inc. and was managed through WESTON's home office in West Chester, Pennsylvania.

1.5.1 WESTON Personnel

The following personnel served lead functions in this project:

MR. PETER J. MARKS, PROGRAM MANAGER: Corporate Vice President and Manager of Laboratory Services, Master of Science (M.S.) in Environmental Science, 18 years of experience in laboratory analysis and applied environmental science.

TABLE 1-2

ANALYTICAL PROTOCOL FOR PROBLEM CONFIRMATION STUDY
NORTON AFB

ZONE	POTENTIAL CONTAMINANTS	MEDIUM	ANALYTES
1. Golf Course Waste Management Zone			
. Landfill No. 1, Waste Pits, Industrial Waste Lagoons	Industrial Chemicals and Heavy Metals	Surface Water	TOC, TOX, VOA inc. MEK, Oil & Grease, Phenol, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, pH and Specific Conductance
		Pond Sediment	VOA incl. MEK, Phenol
		Fish Tissue	Pb, Cr, Ni, Cd, As, Zn, Cu, Hg
		Groundwater	TOC, TOX, VOA inc. MEK, Oil & Grease, Phenol Cyanide, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, pH and Specific Conductance
. Fire Protection Training Area No. 2	Waste Fuel Products, Solvents	Groundwater	
		Soil	VOA, Phenol
2. Landfill Waste Management Zone	Industrial Chemicals, Heavy Metals inc. Li, and Waste Fuel Products	Groundwater	TOC, TOX, VOA, Oil & Grease, Li, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, pH and Specific Conductance
3. Underground Waste Oil Storage Tank	Waste Fuel Products, Lead, Solvents	Groundwater	TOC, TOX, VOA, Oil & Grease, Pb, pH and Specific Conductance
4. IWTP Waste Management Zone	Industrial Chemicals, Heavy Metals, Waste Fuel Products	Soil	VOA, Phenol
		Groundwater	TOC, TOX, VOA, Oil & Grease, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, pH and Specific Conductance
5. Waste Pit No. 4	Paints & Thinners	Groundwater	TOC, TOX, VOA, Oil & Grease, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, pH and Specific Conductance
6. AAVS/DAVA Evaporation Ponds	Inorganic Salts, Industrial Chemicals	Groundwater	TOC, TOX, VOA, Oil & Grease, Cyanide, Pb, Cr, Ni Cd, As, Zn, Cu, Hg, pH and Specific Conductance

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TABLE 1-3

LIST OF USEPA PRIORITY POLLUTANT COMPOUNDS WITH DETECTION LIMITS

COMPOUND	DETECTION LIMIT IN WATER (ug/L)	DETECTION LIMIT, SEDIMENT (ug/g)
Chloromethane	0.08	.0008
Bromomethane	1.18	.0118
Dichlorodifluoromethane	1.81	.0101
Vinyl chloride	0.18	.0018
Chloroethane	0.52	.0052
Methylene chloride	0.25	.0025
Trichlorofluoromethane	1.0	.0100
1,1 Dichloroethene	0.13	.0013
1,1 Dichloroethane	0.07	.0007
Trans 1,2 Dichloroethene	0.10	.0010
Chloroform	0.05	.0005
1,2 Dichloroethane	0.03	.0003
1,1,1-Trichloroethane	0.03	.0003
Carbon tetrachloride	0.12	.0012
Bromodichloromethane	0.10	.0010
1,2 Dichloropropane	0.04	.0004
Trans 1,3-Dichloropropene	0.34	.0034
Trichloroethylene	0.12	.0012
Dibromochloromethane	0.09	.0009
1,1,2 Trichloroethane	0.02	.0002
Cis 1,3-Dichloropropene	0.20	.0020
2-Chloroethylvinylether	0.13	.0013
Bromoform	0.20	.0020
1,1,2,2-Tetrachloroethane	0.03	.0003
Tetrachloroethene	0.03	.0003
Chlorobenzene	0.25	.0025
1,3 Dichlorobenzene	0.32	.0032
1,2 Dichlorobenzene	0.15	.0015
1,4 Dichlorobenzene	0.24	.0024
Benzene	10	.1000
Toluene	10	.1000
Ethylbenzene	10	.1000

MR. FREDERICK BOPP, III, Ph.D., P.G., PROJECT MANAGER: Doctor of Philosophy (Ph.D.) in Geology and Geochemistry, Registered Professional Geologist (P.G.), over 8 years of experience in hydrogeology and applied geological sciences.

MS. ALISON L. DUNN, PROJECT GEOLOGIST: M.S. in Hydrogeology, over three years of experience in hydrogeological site evaluation.

MR. WALTER M. LEIS, P.G., GEOTECHNICAL QUALITY ASSURANCE OFFICER: Corporate Vice President and Manager of the Geosciences Department, M.S. in Geological Sciences, Registered Professional Geologist, over 10 years of experience in hydrogeology and applied geological science.

MR. JAMES S. SMITH, Ph.D., LABORATORY QUALITY ASSURANCE OFFICER: Ph.D. in Chemistry, over 16 years of experience in laboratory analysis.

MR. THEODORE F. THEM, Ph.D., PROJECT CHEMIST: Ph.D. in Analytical Chemistry, over 10 years of experience in laboratory analysis.

Professional profiles of these key personnel, as well as other project personnel are contained in Appendix C.

1.5.2 Subcontractors

Soil borings, drilling and well installation for this project were performed by Stang Hydronics, Inc. of Rancho Cordova and Orange, California.

1.6 FACTORS OF CONCERN

There are several factors which impact the potential for migration of contaminants beyond the installation boundary and which the reader should be aware of in reviewing the following chapters.

- Soils underlying the installation are sandy and highly permeable. The potential for downward migration of contaminants released at the surface is therefore high. This concern is offset somewhat by the very high rate of evapotranspiration in this semi-arid region, which results in a net water loss from the surface during most of the year and tends to slow the progress of contaminants downward.

- Public water supply in the San Bernardino area is primarily from groundwater, supplemented by water imported from other basins (e.g. the Colorado River). The valley alluvium underlying the Base has a high capacity for groundwater storage, and there is a strong public awareness and concern over proper management and conservation of groundwater as a resource.

- As a result of this awareness, management practices have been initiated to conserve groundwater, resulting in a rebound of groundwater levels to near their nineteenth century levels. Areas excavated in the 1950's and 1960's and used for waste disposal, which historically have lain well above the water table may have become inundated as a result of this rise in water levels, and could begin to generate groundwater contamination at newly elevated rates.

SECTION 2

ENVIRONMENTAL SETTING

Sources of information on the environmental setting of Norton AFB include the climatic records of Detachment 14, 17th Weather Squadron (MAC), the U. S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA), streamflow records of the USGS, and the following publications on regional geology and hydrogeology: Dutcher and Garrett (1963), Fife and others (1976), Jennings and others (1977), Rogers (1977), CDWR (1970, 1975, 1980), Rowe and others (1979), Martin (1979), Hill (1979) and Hardt and Hutchinson (1978, 1980). These sources and additional information from interviews with personnel from the U.S. Geological Survey and several State and regional agencies were summarized by ESI (1982) in the IRP Phase I Report for Norton AFB. That report has been used as the primary source document for the following chapter.

2.1 GEOGRAPHY

Norton AFB (NoAFB) is located in the San Bernardino Valley within the Pacific Coast Peninsular Ranges Physiographic Province. This is an area of narrow folded and faulted bedrock mountain ranges trending northwest-southeast and separated by longitudinal, nearly flat alluvial valleys. The San Bernardino Valley (Figure 2-1) is a semi-arid inland basin in the eastern part of the Upper Santa Ana River valley. It is bounded on the northwest by the San Gabriel Mountains, on the northeast by the San Bernardino Mountains, on the south by Grafton Hills, the Badlands and Box Springs Mountain, and to the southwest by a low escarpment of the San Jacinto fault.

The floor of the valley is a relatively flat alluvial plain, slightly dissected by stream valleys, and sloping to the southwest at 30 to 50 feet per mile. Relief at Norton AFB ranges from approximately 1160 feet above Mean Sea Level (MSL) along the east boundary to 1035 feet along the west boundary.

The climate in the valley is semi-arid. The mean annual temperature in the San Bernardino area is 62° F. Monthly averages at Norton AFB for the period from 1943 to 1980 ranged from 50° in January to 78° in July and August

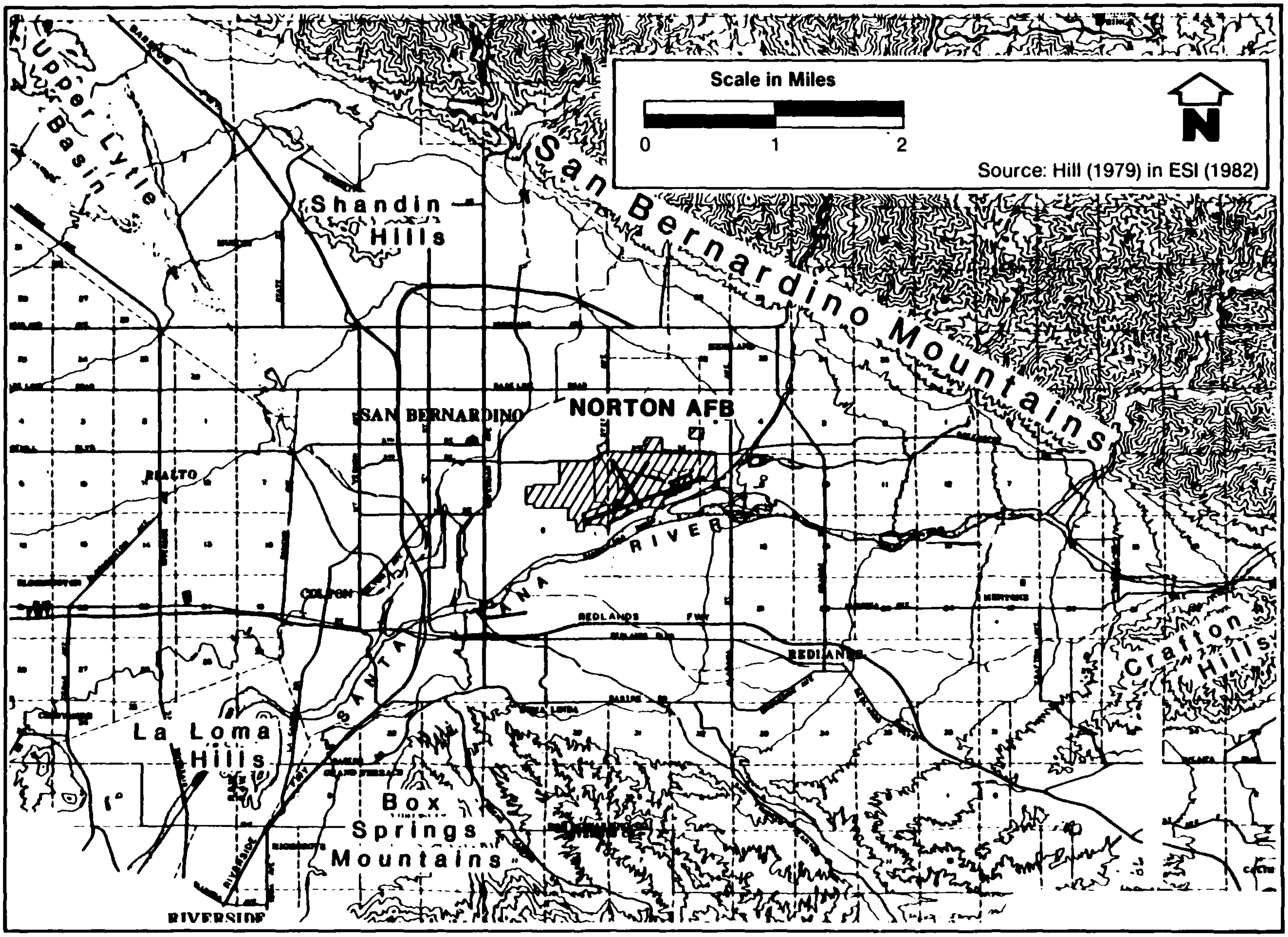

FIGURE 2-1 PHYSIOGRAPHIC SETTING OF NORTON AFB

(ESI, 1982). Average annual precipitation during the same period was 12.78 inches at NoAFB. In an average year, 80 percent of the precipitation falls during the five month period from December through April. Total annual precipitation is highly variable, exhibiting year-to-year departures from the mean of up to 20 inches (Dutcher and Garrett, 1963). Precipitation varies areally also, from a low of 10-14 inches per year at the center of the valley to as much as 28 inches on the flanks of the mountains to the north, due to orographic effects. ESI (1982) estimated the average annual net precipitation (or actual precipitation minus potential evapotranspiration) in the vicinity of NoAFB at -41 inches.

Surface drainage in the area of Norton AFB is provided by the Santa Ana River and its tributaries, City and Twin Creeks. All are ephemeral streams, dry most of the year. The Santa Ana River Wash borders the southern boundary of NoAFB, and a portion of the Base is located in the 100-year floodplain.

Storm runoff from the Base area is carried through a system of ditches and storm drains (Figure 2-2). The southern portion of the Base drains directly to the Santa Ana, the northern portion drains to City Creek, and the western section drains to the Twin Creek flood control channel. City and Twin Creeks feed Warm Creek, a permanent stream which joins the Santa Ana at Colton.

Native soils on the Base were mapped by the USDA Soil Conservation Service in 1980. Approximately ninety percent of the Base area is covered with Tujunga Series gravelly loamy sand and coarse sand. All soils mapped were sandy, extremely well drained, and subject to erosion. Estimated soil permeabilities ranged from 2.0 to over 20.0 inches/hour.

2.2 GEOLOGY

2.2.1 General

The San Bernardino valley consists of a bedrock trough filled with Quaternary Age alluvium over 1000 feet thick in the center. The mountains to the north (the San Bernardino and San Gabriel Mountains) are complex, faulted bedrock blocks that have been uplifted along major regional faults (i.e. the San Andreas and San Jacinto faults). The

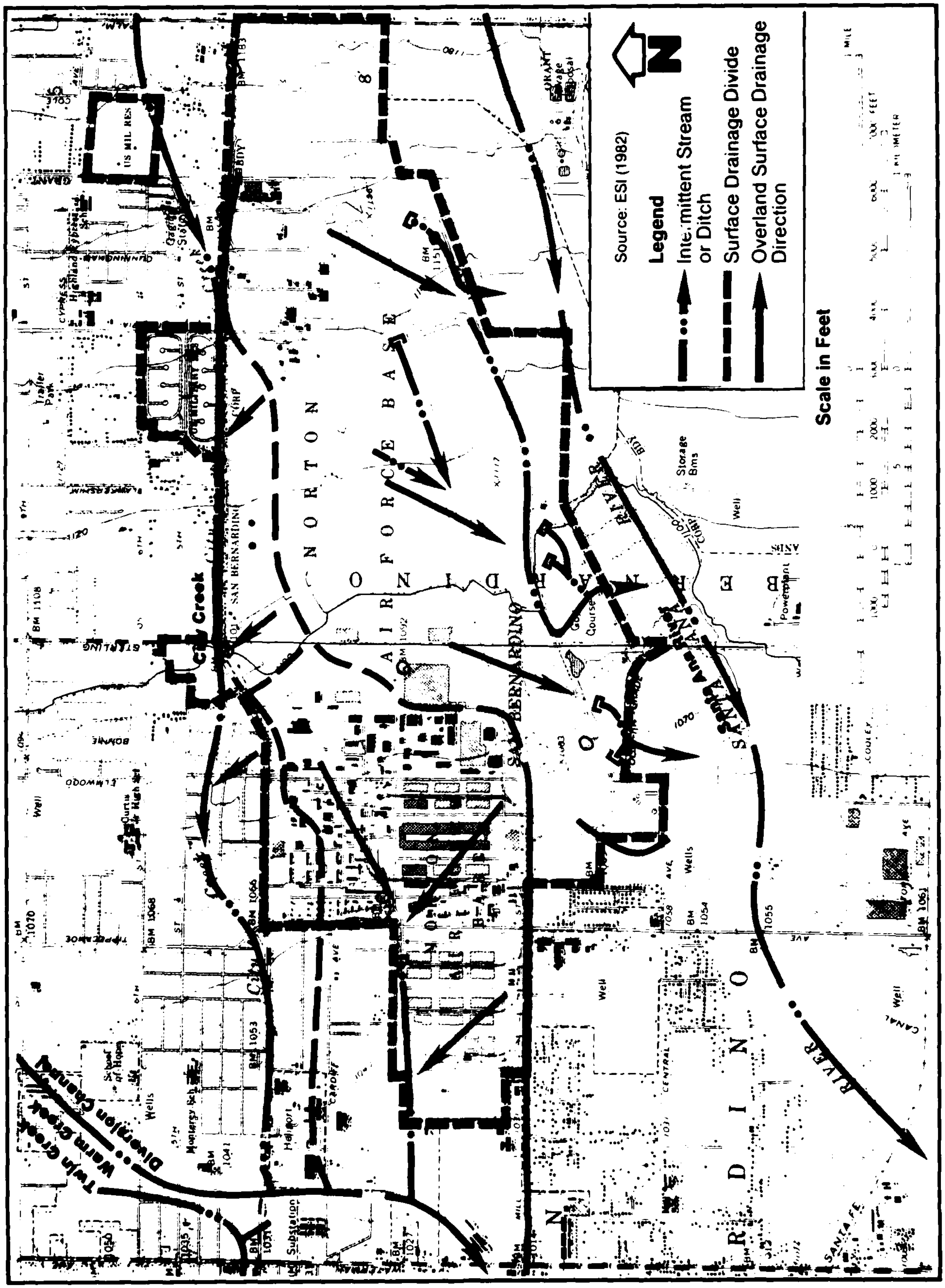

FIGURE 2-2 SURFACE DRAINAGE MAP OF NORTON AFB

mountains and hills to the south consist of either outcrops of resistant crystalline bedrock (i.e. Box Springs and Grafton Mountains) or terraces of dissected, relatively unconsolidated Tertiary to Quaternary Age continental sedimentary deposits. Bedrock topography beneath the valley is highly complex, characterized by numerous bedrock hills, the tops of which may occur at shallow depths below the valley floor or protrude above the alluvium (e.g. Shandin Hills, La Loma Hills).

Quarternary Age sediments in the valley were deposited in a series of coalescing alluvial fans emanating from the mountains to the north and northeast, and spreading as the mountains rose higher shedding more eroded sediment. In general, the thickness of alluvial sedimentary deposits increases and particle size decreases away from the mountain fronts and toward the center of the valley. Thus, bouldery, gravelly deposits are found most commonly in the foothills or the mountain flanks, and clayey and silty deposits in the center of the valley where sediment transport energy is lowest. However, boulder and gravel deposits can be carried far into the valley along major stream channels, and ribbons of coarser stream channel sediments are locally found buried beneath fine-grained deposits in the valley center.

In recent times, the surface of the alluvial plain has been entrenched by the Santa Ana River and its tributaries. Along these stream washes surface fan deposits have been reworked and new sediments added to form the youngest deposits in the valley, the River-Channel Deposits.

2.2.2 Stratigraphy

The lithology and water-bearing properties of the major stratigraphic units identified in the San Bernardino Valley were summarized in Table 2-1. Figure 2-3 shows general surface geology in the vicinity of Norton AFB. The primary surface units of interest are the Younger Alluvium (as distinguished from the Older Alluvium of the fan deposits) and the River-Channel Deposits, both of Quaternary Age. Fife and others (1976) further differentiated within the Younger Alluvium between "Undifferentiated Younger Alluvium" and "Alluvial Fan Deposits" covering most of the area of NoAFB. Both Younger Alluvium and River-Channel Deposits consist of boulders, gravel, sand, silt and clay occuring under varying degrees of sorting in beds with little lateral continuity. Areally, the coarser fraction increases toward

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TABLE 2-1

STRATIGRAPHIC UNITS OF THE SAN BERNARDINO AREA, CALIFORNIA

GEOLOGIC AGE	FORMATION	THICKNESS	GENERAL LITHOLOGIC CHARACTER	WATER-BEARING PROPERTIES
QUATERNARY Recent	Dune sand	0-50±	Sand, coarse to fine, well-rounded; contains some fluvial pebbles but is largely eolian; generally anchored by vegetation but in part loose and drifting.	Unconsolidated and permeable but above the sone of water-level fluctuation.
	Local unconformity			
	River-channel deposits	0-25±	Boulders, coarse gravel, sand, and silt in the channels of Santa Ana River and Lytle, Cajon City, Warm, East Twin, Plunge, Mill, Devil Canyon, and San Timoteo Creeks; generally becomes progressively finer grained at greater distance from the heads of the canyons. Mapped area includes bottom lands along the Santa Ana River.	Unconsolidated and permeable but generally above the sone of water-level fluctuation, except along the Santa Ana River and Warm Creek just east of Colton narrows. Large quantities of water seep from the Santa Ana River, Lytle Mill, and Cajon Creeks, and smaller streams into thse deposits when runoff occurs.
	Local unconformity			
	Younger alluvium	0-125±	Boulders, gravel, sand, silt, and clay; underlies San Bernardino Valley, Fontana plain, and river-bottom lands from Colton narrows westward to the margin of the area and beyond. Generally coarse grained throughout Fontana plain, river-bottom lands, and margins of San Bernardino Valley. Unconformably overlies basement complex, older alluvium, and Tertiary to Quaternary continental deposits. Not known to be cut by faults, except along Cucamonga fault system. Consists locally of two members, which are distinguishable in the area immediately above Colton narrows. Upper member, 60 to 90 feet thick, is largely clay, the lower member is largely gravel and sand.	Unconsolidated and permeable. Yields water to wells at rates of as much as 800 gpm but generally beause of shallow penetration yields 400 to 500 gpm. Permeability, 2,000 to 3,000 gpd per sq. ft. Upper member in places is poorly permeable and confines water in lower member under artesian pressure.
	Unconformity			
TERTIARY Pleistocene (late)	Older alluvium	0-800±	Gravel, sand, silt, and clay of continental, largely fluvial, origin, generally unconsolidated, but in places deeply weathered to form red or yellow soil zones; usually contains easily broken pebbles of dioritic and granitic gneiss. Crops out along the margins of the valley area and is extensively exposed along the southern and eastern margins of Rialto-Colton basin. Locally unconformably overlies crystalline bedrock, Tertiary continental deposits in the north-western part of Rialto-Colton basin, and Tertiary to Quaternary continental waterbearing deposits, and unconformably underlies Recent dune sand and younger alluvium. East of the San Jacinto fault it locally contains numerous clay lenses that act as imperfect confining members and give artesian pressure to water contained in deeper permeable members. Fractured by numerous faults and, in places, slightly folded.	Unconsolidated and permeable; principal aquifer in report area. Yields water to wells at rates of as much as 4,500 gpm but averages about 1,000 to 1,500 gpm. Yields from flowing wells have been as much as 4,500 gpm but averages about 1,000 to 1,500 gpm. Yields from flowing wells have been as much as 4,500 gpm in the central part of Bunker Hill basin, but maximum yields are about 3,000 gpm elsewhere. Water movement interrupted by several hydrologic barriers.
	Local unconformity			
TERTIARY Pleistocene (early)	Tertiary to Quaternary continental deposits	0-1,500(?)	Gravel, sand, silt, and clay, somewhat compacted in discontinuous lenticular bodies exposed in badlands south of San Bernardino Valley between San Jacinto and San Andreas faults; unconformably overlies Tertiary continental rocks; somewhat indurated where exposed at the surface; contains rich mammalian fauna; broken by numerous faults.	Poorly consolidated; yields water to wells at rates of as much as 900 gpm, but averages about 500 gpm. Contains aquifers through which ground water percolates from San Timoteo basin to Bunker Hill basin. Ground-water movement from Bunker Hill basin to Rialto-Colton basin interrupted by San Jacinto fault.
(Cont'd) ?	Unconformity			
Pliocene	Tertiary continental rocks	0-1,500(?)	Predominantly brown to blue-green calcareous indurated clays and local discontinuous lenses of sand, compacted, cemented calcareous, in places laminated; and beds of conglomerate; base is not reached by wells but these rocks presumably rest unconformably on the basement complex.	Consolidated and virtally not water bearing, not exposed at the surfce within the project area; probably penetrated by wells in northern Rialto-Colton basin and eastern Bunker Hill basin.
	Unconformity			
PRE-TERTIARY	Basement complex (undifferentiated rocks)		Metamorphic and igneous rocks, principally dioritic rocks but quartz monzonite, granite, schist, dioritic and granitic gneiss, marble, and other metamorphic rocks are included.	Consolidated and virtully not water bearing except for water in fractures; probably supplies little water to the area; water tunnels penetrating fratures yield small quantities of water locally; not tapped by wells.

Source: Dutcher and Garrett (1963)

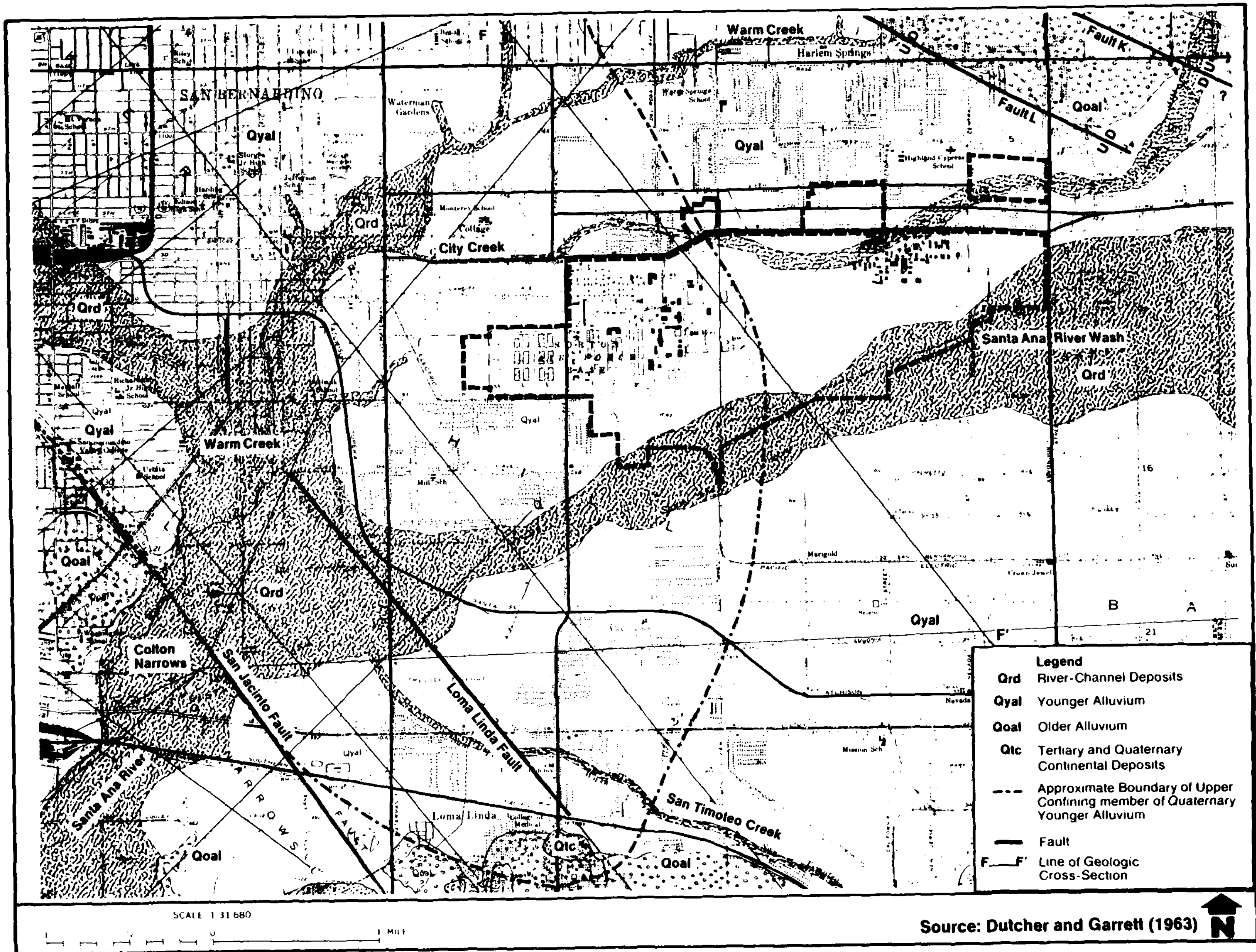


FIGURE 2-3 GENERALIZED SURFACE GEOLOGY IN THE VICINITY OF NORTON AFB

the river channel. Surface deposits over most of Norton AFB consist of sand with a high fraction of gravel and boulders. Vertically, two members are commonly distinguished within the Younger Alluvium in the central valley area, including the western half of Norton AFB: the upper member, 60-90 feet thick, largely composed of clay although overlain near the surface by sand and gravel, and the lower member, largely composed of gravel and sand (Dutcher and Garrett, 1963). The Younger Alluvium grades downward into the Older Alluvium, also consisting primarily of gravel and sand with numerous silt and clay lenses. The total thickness of unconsolidated deposits beneath the Base varies from 700 to 1200 feet, east to west.

2.2.3 Structure

The region is crossed by numerous faults trending primarily northwestward. The San Andreas fault forms the valley boundary to the northeast. Three other major faults parallel the San Andreas and appear to cross the entire width of the valley. Moving southward, these are the Loma Linda, San Jacinto and Rialto-Colton faults. Sub-branches of these faults and several other discrete faults were mapped by Dutcher and Garrett (1963) and by other authors. Most of these faults cut through the Older Alluvium but not the Younger Alluvium, and therefore have no surface expression on the valley floor. They have been identified through well log correlation and through their effects on groundwater levels. Due to lateral and vertical movement along these faults, offset of lithostratigraphic beds occurs, often resulting in juxtaposition of less permeable beds against water-bearing units. In addition, the presence of clayey fault gouge or secondary cementation in the fault zone may further accentuate the role of a subsurface fault as a barrier to groundwater. This barrier effect is detected through anomalous offset in groundwater levels between adjacent wells.

The San Jacinto, like the San Andreas, is a currently active fault and is marked by a surface escarpment. It acts as a major regional groundwater barrier, dividing the San Bernardino Valley into separate groundwater basins. The upper basin, within which Norton AFB is located, is termed the Bunker Hill Basin (Dutcher and Garrett, 1963).

2.3 HYDROGEOLOGY

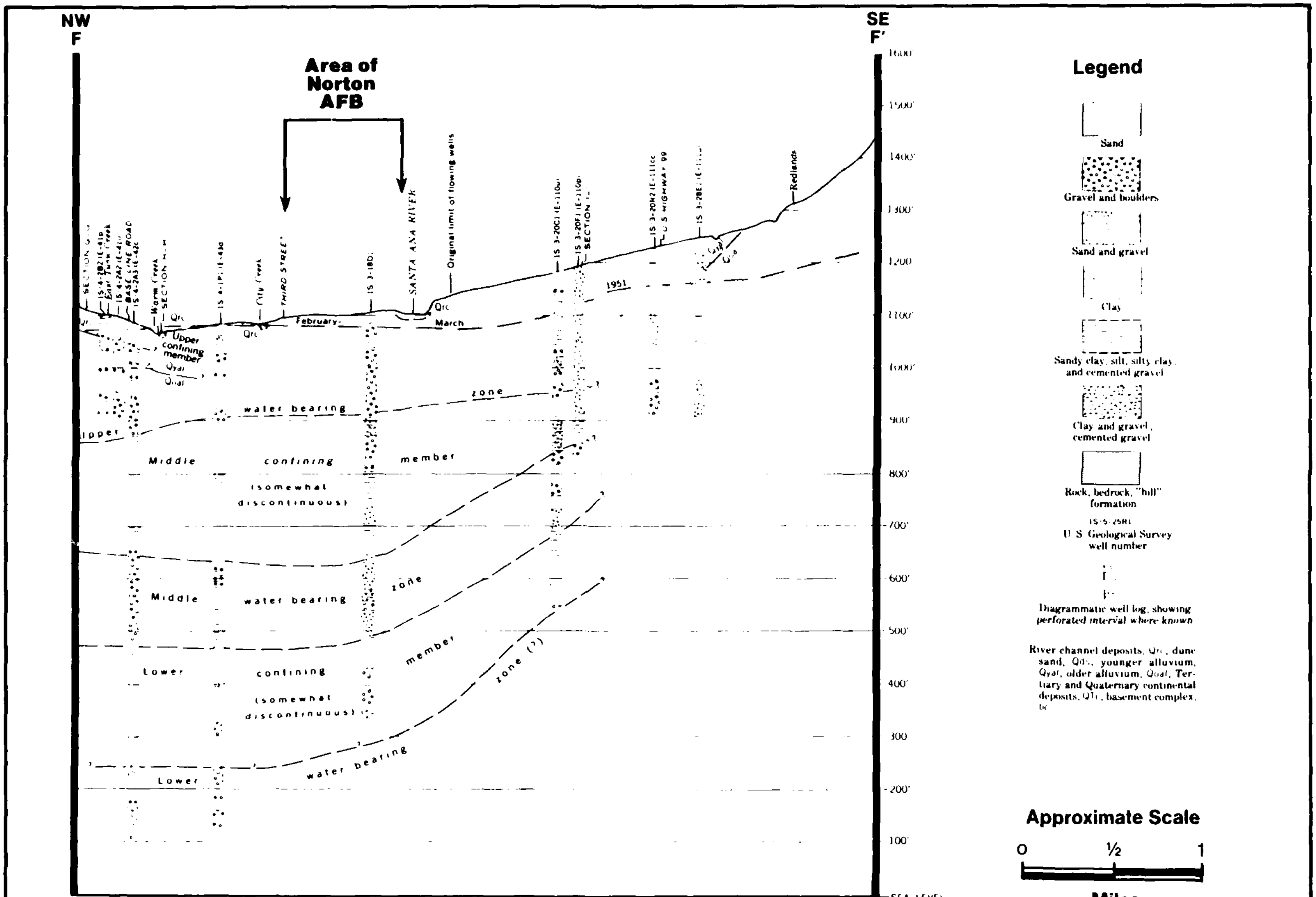
2.3.1 Hydrogeologic Units

Figure 2-4 is a geologic cross-section through the San Bernardino valley, including the area of Norton AFB (the line of cross-section is shown on the map in Figure 2-3). Dutcher and Garrett (1963) identified three separate water-bearing zones, consisting primarily of sand and gravel, separated by two confining members consisting of somewhat discontinous lenses of silt and sand having low-permeability layers from 50 to 300 feet thick. In addition, they identified an upper confining member which overlies the upper water-bearing zone in the center of the valley. The approximate areal extent of this upper member is shown in Figure 2-3. Hardt and Hutchinson (1980) showed that the two lower water-bearing zones essentially function as a single aquifer. In their simplified conceptual model of the hydrogeology of the Bunker Hill Basin, the valley floor is underlain by two aquifers. The Lower Aquifer is 500 to 700 feet thick, and separated from the Upper Aquifer by a semi-permeable confining bed 200 to 300 feet thick (the Middle Confining Member). Major supply wells in the area, including the NoAFB wells, are screened in the Lower Aquifer (ESI 1982). The Upper Aquifer (which includes sediments from the upper Older Alluvium, the Younger Alluvium, and Recent Stream-Channel Deposits) is unconfined in the east and confined in the west by a clay layer (the Upper Confining Member) which thickens westward, reaching a maximum thickness of 60 to 90 feet at the San Jacinto Fault. The eastern edge of this upper confining layer occurs beneath Norton AFB.

2.3.2 Regional Hydrogeology and Historic Trends

Norton AFB is located in the Bunker Hill Groundwater Basin. This basin is bounded on the north, east and south by bedrock mountains and sedimentary hills. On its southwestern and western end, it is bounded by a system of barrier faults including portions of the San Jacinto and Loma Linda faults and smaller, associated sub-parallel faults.

The primary source of water in the basin is recharge. Although some recharge occurs directly from precipitation over the entire valley, the major portion is derived from runoff from the bedrock mountains to the north, northeast



Source: Dutcher and Garrett (1963)
Note: Numbers refer to USOS Well Identification Numbers

FIGURE 2-4 GEOLOGIC CROSS-SECTION THROUGH THE SAN BERNARDINO VALLEY IN THE VICINITY OF NORTON AFB

and southeast. This is due to a combination of factors, including higher precipitation rates in mountain areas, low recharge rates into the bedrock, and the high permeability of the coarse fan deposits at the mountain fronts. In addition, recharge to the valley floor occurs through the highly permeable channel deposits of the major streams (i.e. the Santa Ana River, Mill Creek) during periods of surface flows in the wet months.

The Bunker Hill Basin is not a "closed" or discrete groundwater basin. A secondary source of water occurs as groundwater underflow into the Bunker Hill Basin from the San Timoteo Basin to the south through the Tertiary to Quaternary Age deposits of the Badlands area.

From intake areas at the edge of the basin, groundwater flows downward and inward to the valley center, ponding up behind the San Jacinto and associated barrier faults, where it moves upward and "spills over" into the Colton-Rialto basin to the southwest. Groundwater discharge from the Bunker Hill Basin is concentrated through the Colton Narrows where groundwater flows out of the Basin primarily through the Upper Younger Alluvium and Recent Channel Deposits below the channel of the Santa Ana River. Before development of the area in the 19th century, the central part of the valley east of the San Jacinto Fault was occupied by marshes and bogs. Streams were perennial, and excess groundwater was discharged from the basin both as surface and groundwater overflow into the Colton-Rialto basin, and as evapotranspiration. Early wells in this area exhibited artesian heads as great as 50 feet above land surface, indicating a very strong upward component of groundwater flow. The groundwater flow direction in this area, referred to as the "Artesian Area", is still primarily upward. Warm Creek, which flows southward to its confluence with the Santa Ana at Colton Narrows, has remained a perennial stream, indicating that it has been continuously fed by upward moving groundwater. Based on historical evidence, the natural vertical component of flow beneath most of NoAFB would be upward, if groundwater indications were not influenced by pumping.

Horizontal flow directions can be determined from piezometric maps, as shown in Figure 2-5. Comparison of groundwater level contours for 1951 and 1979 indicates that the general direction of regional flow beneath NoAFB is to the southwest toward Colton Narrows. Although the basic

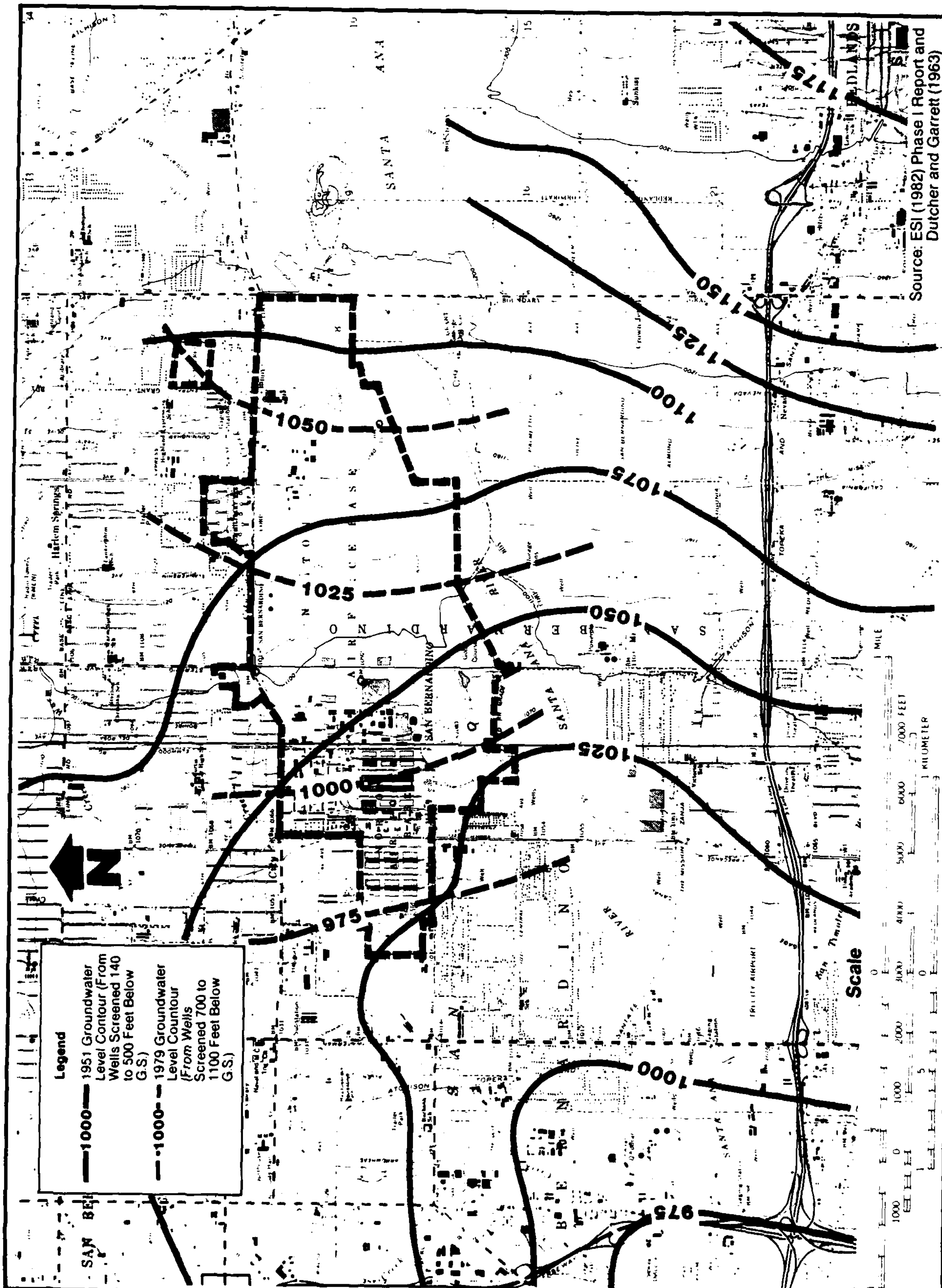


FIGURE 2-5 REGIONAL GROUNDWATER LEVELS, 1951 AND 1979

flow directions in the basin are determined by the rates of natural recharge and geologic composition and structure of the subsurface, they have been modified over the years by human activities. In the late 19th century and the first half of the 20th century, groundwater resources of the area were excessively developed, primarily for agriculture. Large-scale pumping resulted in depressed groundwater levels (with drops from 10 to over 100 feet) and drying of the valley floor. In response, groundwater management practices including permitting of consumptive uses, installation of artificial recharge facilities, and importation of water from Northern and Eastern California were instituted (ESI 1982). These measures have been very successful, resulting in a groundwater level rebound which began in the 1970's and is continuing today. Some less desirable side-effects of this rebound have included break-outs of artesian water under paved surfaces and buildings due to upward movement of pressurized groundwater through improperly sealed abandoned wells (ESI, 1982). Another potential undesirable effect would be the submergence of old wastes, once buried in unsaturated soil, which have become saturated due to the rising groundwater levels, potentially resulting in increased release of contaminants from these wastes.

2.3.3 Base Supply and Other Area Wells

Norton AFB is supplied by three deep wells located on Base and obtains supplementary water from the City of San Bernardino as necessary. Specifications for the three active wells and one inactive supply well are given in Table 2-2. The location of these wells and nearby municipal and agricultural wells monitored by the California Department of Health Services (CDHS) are shown in Figure 2-6.

ESI (1982) mapped 44 inactive or abandoned water wells on Norton AFB property, based on installation documents and Dutcher and Garrett (1968). Most of these wells predate the construction of NoAFB. Their approximate locations are shown in Figure 2-7. However, there is no visual evidence of these wells at the surface, and no actions have been taken to seal them.

2.3.4 Groundwater Quality

Results of 269 water analyses evaluated by Dutcher and Garrett (1963) indicated that water recharged to the Bunker Hill Basin was of good quality and suitable for most uses. Samples of water taken in the groundwater discharge area of Colton Narrows from the base flow of the Santa Ana River and nearby wells were similar in composition, indicating that relatively little natural mineralization or degradation of groundwater had occurred in its passage through the Bunker Hill Basin. The most mineralized water, having total

TABLE 2-2

SUPPLY WELL SPECIFICATIONS, NORTON AFB

CDHS/ BASE NOS.	ORIGINAL CONSTRUC. DATE	DEPTH	CASING	STATIC WATER LEVEL (FEET BELOW GRADE[1]	AVERAGE PROD. (GPM)
34/2	1907	818'	10"	121 (1972)	653 (1972)
-/3	1902	298'	10"	120 (1972)	110 (1972)[2]
33/5	1952	1100'	20"	90 (1974)	2300 (1974)
35/11	1959	733'	16"	142 (1974)	1400 (1974)

Notes:

1 - Current water level data not available

2 - Abandoned

Source: ESI, 1982

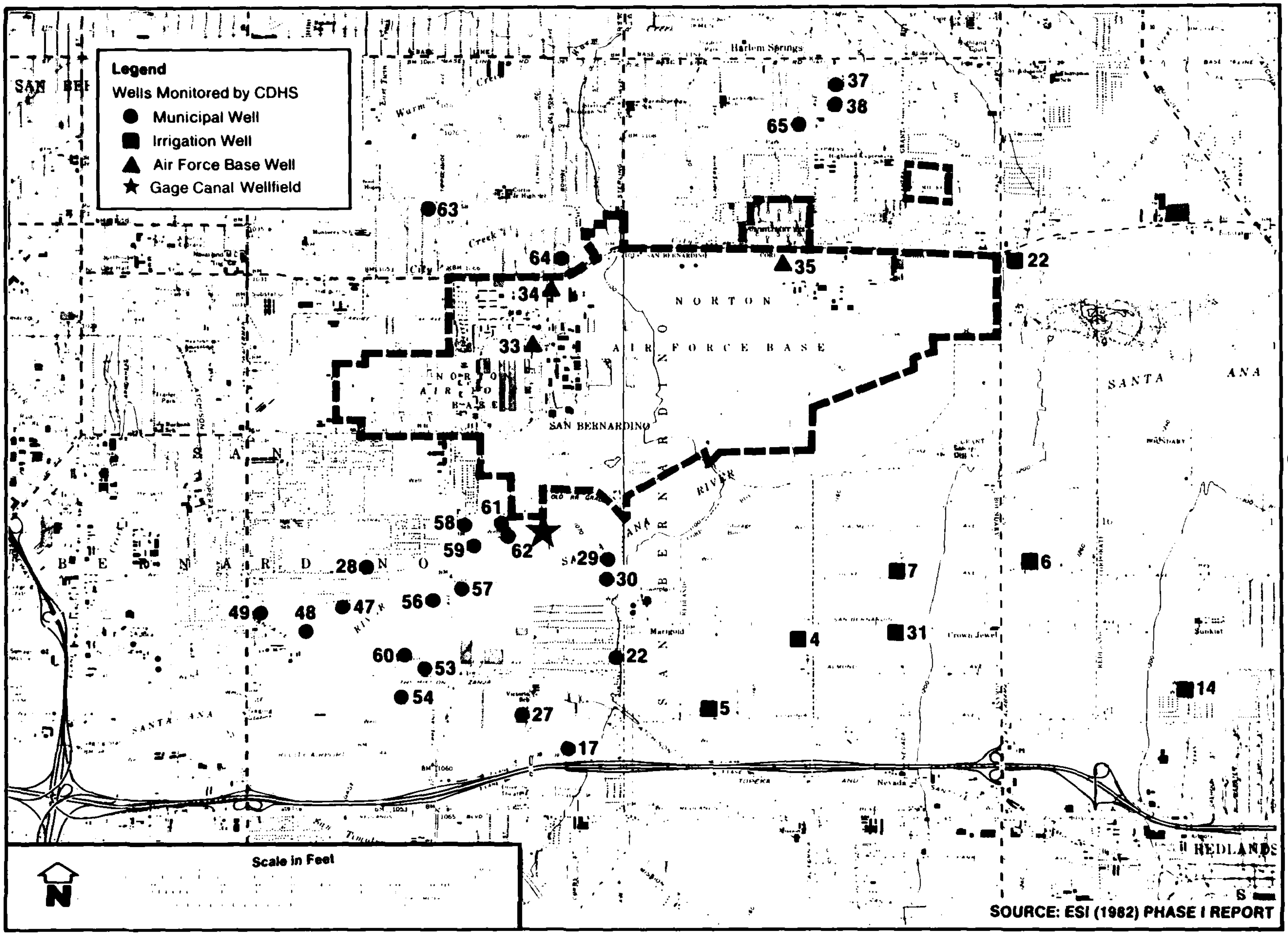


FIGURE 2-6 LOCATION OF MAJOR SUPPLY WELLS AT NORTON AFB AND VICINITY

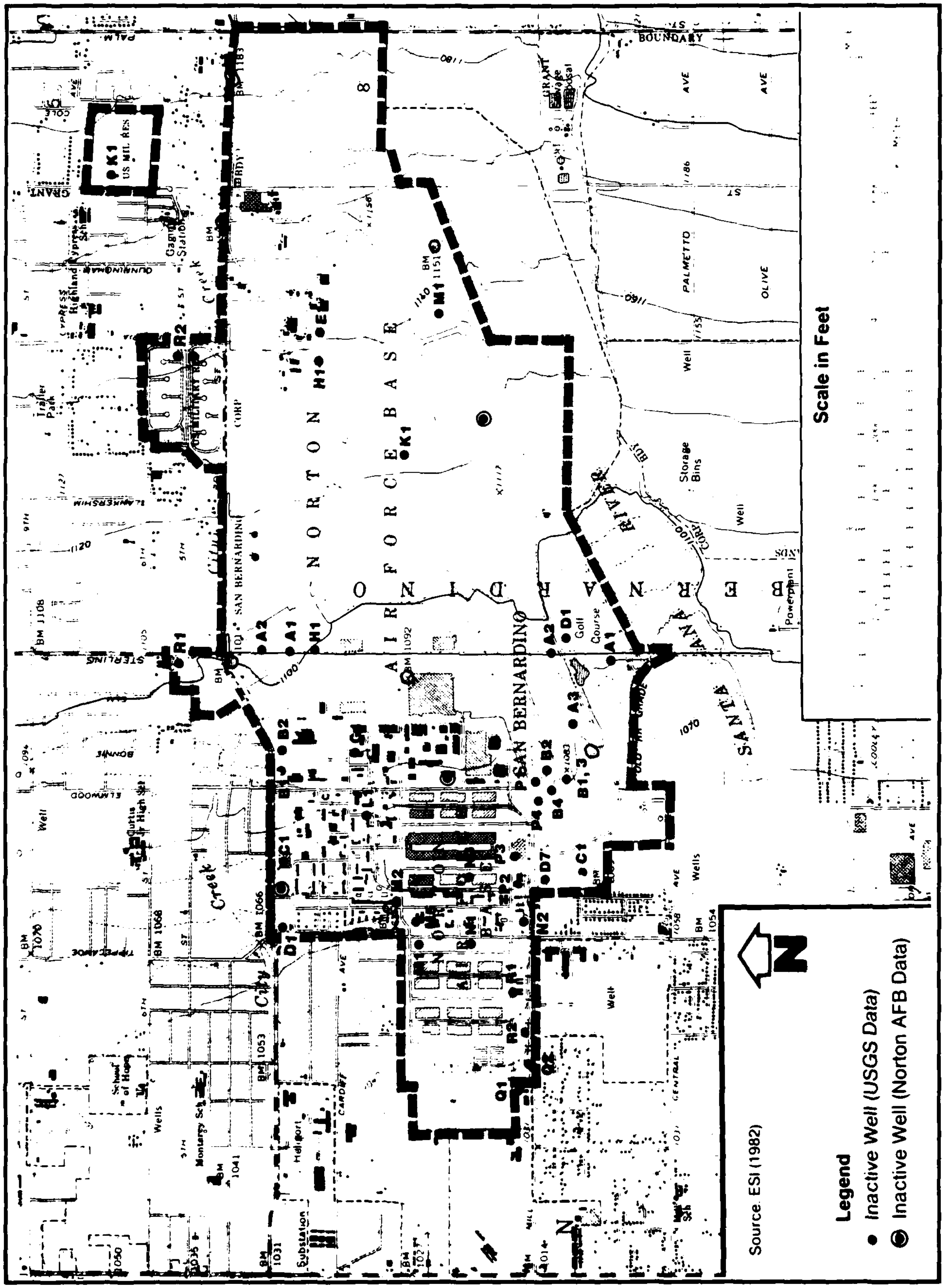


FIGURE 2-7 LOCATION OF INACTIVE WELLS AT NORTON AFB

dissolved solids concentrations (TDS) of 406 to 447 ppm, is recharged from creeks draining the Teriary to Quaternary Age deposits of the Badlands area. Water recharged from creeks draining the bedrock areas has a TDS from 74 to 217 ppm and is most commonly of the calcium bicarbonate type.

A certain degree of groundwater contamination related to human activities has occurred in the basin and has been the focus of several recent hydrologic investigations. Excessive irrigation demands and water shortages in the basin have resulted in salt build-up, aggravated by the lack of a brine wastes export system (ESI, 1982). This has resulted in a general increase in groundwater in TDS, hardness, and locally excessive concentrations of nitrate, boron, chloride and sulfate.

Point sources of groundwater contamination may correspond to industrial and municipal discharges, which are normally discharged to surface water but ultimately are recharged to the ground through dry river bottoms. ESI (1982) identified six discharge points upstream from or adjacent to Norton AFB on or near the Santa Ana River Wash, which would potentially be affecting groundwater quality upgradient from NoAFB. These are listed in Table 2-3. Table 2-4 lists discharge points on the installation itself which are regularly sampled by the U.S. Air Force.

The quality of the Base water supply system is generally good. Slightly elevated levels of silver have been detected (ESI, 1982) ranging from 11 to 29 ug/l, well below the Federal Primary Drinking Water Standard of 50 ug/l. The solvent trichloroethylene (TCE) has been detected in Base Well 11 at concentrations ranging from 1.5 to *6.2 ug/l. Nearby Gage Canal Company wells (Numbers 56, 57, 58, 59 and 61 on Figure 2-5) located south of the Base have exhibited TCE concentrations from 0.17 to 2.3 ug/l and perchloroethylene (PCE) concentrations from 0.12 to 2.5 ug/l (ESI, 1982).

*The 6.2 ug/l sample was noted by California Department of Public Health on 29 Sep. 80. A sample 42 days previous to this was 1.7 ug/l, and all subsequent samples have been less than 1.7 ug.l.

TABLE 2-3

POINT SOURCES OF POTENTIAL CONTAMINATION NEAR NORTON AFB

Facility Name	Approximate Distance Upstream from NoAFB (in miles)	Description/ Comments
1. Southern California Edison Power Plant	0	Direct discharge to Santa Ana River
2. City of Redlands Sewage Treatment Plant	0	Direct discharge to Santa Ana River
3. Universal Rundle Co.	2.5	Discharge to percolation ponds draining to Santa Ana River
4. City of Redlands Municipal Landfill	0.5	
5. Plunge Creek Flood Dikes	3	Dikes reportedly constructed of municipal fill material
6. Rock Products Plant	1.5	Permitted disposal of municipal sewage by septic tank cleaning contractors into a gravel pit

TABLE 2-4

SURFACE WATER SAMPLING POINTS AT
NORTON AIR FORCE BASE

Sampling Point No.	Description	Sampling Frequency	Monitoring Required by	Comments
1	Flight Line Apron Stormwater Stream	Intermittent	NPDES Permit CA 0002071	Normally dry. Sampled only after heavy rainfall when flow occurs.
2	"C" Street Stream	Semi-annually	Installation Policy	
3	Industrial Waste Treatment Plant	(a) quarterly (b) monthly	NPDES Permit CA 0002062	Sulfate concentrations have exceeded 0.95 mg/l limitation. Bypass of raw waste reported to have occurred during October, 1981.
4	"C" Street Sanitary Sewer	Semi-annually	S.B. Municipal Code 13.32	
5A	Golf Course Septic Tank	Bi-monthly	SARWQCB No. 79-190	Estimated annual discharge 560,000 gallons.
5B	ILS Trailer Septic Tank	Bi-monthly	SARWQCB No. 79-190	Estimated annual discharge 15,000 gallons.
5C	Firing Range Septic Tank	Bi-monthly	SARWQCB No. 79-190	Estimated annual discharge 40,000 gallons.
5D	Treatment Plant Septic Tank	Bi-monthly	SARWQCB No. 79-190	Estimated annual discharge 19,000 gallons.
6	Defense Audio Visual Agency Cooling Towers (2 each)	Bi-monthly	SARWQCB No. 79-190	French drains; estimated annual discharge 130,000 gallons. Changed to sanitary sewer in 1982.
7	Defense Audio Visual Agency Rinse Water	Once per hour during operation	Installation Policy	This stream monitored prior to discharge to sanitary sewer.

NOTES:
1. Abbreviations:
   a. NPDES - National Pollutant Discharge Elimination System
   b. SARWQCB - Santa Ana Regional Water Quality Control Board
2. Source: Norton AFB Installation Documents, in ESI (1982)

SECTION 3

FIELD PROGRAM

3.1 PROGRAM DEVELOPMENT

Task Order 0021 (included as Appendix B) was issued on the basis of the Phase II Pre-Survey Report and later modifications. Twelve sites were recommended for Confirmation Stage work in the Phase I report. Clean-up was performed at two of these sites by Norton Air Force Base, independently of the Installation Restoration Program. All of the remaining ten recommended sites, plus four additional rated sites, and one additional unlisted site (not rated in the Phase I Report) were addressed in this Phase II, Stage 1, Problem Confirmation Study.

For efficiency in the field and ease of discussion, the fifteen sites addressed in the Phase II program were grouped into six zones, although some site-specific investigations were also performed. The field program approved in the Task Order (Appendix B) is summarized in Table 3-1, which includes both site-specific and general zone activities. The following text briefly discusses the rationale followed in program development in general and for each zone specifically.

3.1.1 General Considerations

The purpose of a Phase II Confirmation Stage investigation is primarily to establish the presence or absence of contamination at a site, and secondarily to provide supplementary information to the Phase I evaluation of the potential for contaminant migration from a site. These purposes dictated the general approach used in developing the proposed field program, including the use of Ground Penetrating Radar (GPR), soil borings, the location and construction of monitor wells, and groundwater and surface water sampling.

3.1.1.1 GPR Surveys

Ground Penetrating Radar (GPR) was used in Zone 1 at those sites where sources of contamination (e.g. old landfill area and waste lagoons) were suspected of existing buried beneath

TABLE 3-1

SUMMARY OF FIELD ACTIVITY

ZONE	SITE	ACTIVITY
1. Golf Course Waste Management Zone	1. Industrial Waste Lagoons (Ponds 2 and 3)	Perform GPR Survey. Sample surface water, bottom sediment and fish tissue in Ponds 2 and 3.
	3. Waste Pit No. 2	Perform GPR Survey.
	4. Waste Pit No. 1 (Pond 1)	Perform GPR Survey. Sample surface water, bottom sediment and fish tissue in Pond 1.
	5. Fire Protection Trng. Area	Drill six soil borings; sample for VOA and Phenol.
	10. Landfill No. 1	Perform GPR Survey.
	12. Waste Pit No. 3	Perform GPR Survey.
		General: Install 9 monitor wells; sample wells for TOC, TOX, VOA incl. MEK, Oil and Grease, Phenol, Cyanide, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, Field pH and Specific Conductance. Perform well and groundwater elevation survey.
2. Landfill Waste Management Zone	2. Landfill No. 2 11. Fuel Sludge Disposal Area	General: Install 3 monitor wells; sample wells for TOC, TOX, VOA, Oil and Grease, Li, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, Field pH and Specific Conductance. Perform well and groundwater elevation survey.
3. Underground Waste Oil Storage Tank	6. Underground Waste Oil Storage Tank	Install 1 monitor well. Sample well for TOC, TOX, VOA, Oil and Grease, Pb, Field pH and Specific Conductance. Perform well and groundwater elevation survey.
4. IWTP Waste Management Zone	7. IWTP Sludge Drying Bed 13. IWTP Sludge Disposal Area	General: Install 4 monitor wells. Sample wells for TOC, TOX, VOA, Oil and Grease, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, Field pH and Specific Conductance. Perform well and groundwater elevation survey.
	17. Drummed Waste Storage Area/ Waste Fuel and Solvent Sump IWTP Discharge Ditch	Drill six soil borings; sample for VOA and Phenol.
5. Waste Pit No. 4	14. Waste Pit No. 4	Install 1 monitoring well. Sample well for TOC, TOX, VOA, Oil and Grease, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, Field pH and Specific Conductance. Perform well and groundwater elevation survey.
6. AAVS/DAVA Evaporation Basins	16. AAVS/DAVA Evaporation Basins	Install 4 monitoring wells. Sample wells for TOC, TOX, VOA, Oil and Grease, Cyanide, Pb, Cr, Ni, Cd, As, Zn, Cu, Hg, Field pH and Specific Conductance. Perform well and groundwater elevation survey.

current grade. GPR measures contrasts in the electrical properties of subsurface materials and can detect interfaces between zones of varying properties reflecting lithologic or chemical differences between those zones. As such, it is a useful tool in remote sensing investigations of buried sites for delineating zones of subsurface disturbance, and for directing further subsurface sampling.

3.1.1.2 Monitor Wells

Contamination discharged on or near ground surface would be expected to be found in highest concentrations in the soils and in the shallowest groundwater underlying a site. At sites where the source of contaminant discharge had been buried or could not be accurately located, monitor wells were emplaced adjacent to and downgradient from the source to sample shallow groundwater for indicators of contamination. For the purposes of monitoring shallow groundwater only, the monitoring wells at NoAFB were to be drilled 20 feet beyond the point where saturated sediment was first encountered. In some cases, water occurred under confined conditions, rising into the well above the top of the actual aquifer, so that the height of the water column varies from well to well. Wells were constructed of 2-inch diameter threaded PVC pipe for economy and ease of sampling. The wells were completed in the saturated zone with wire-sound, sonic-welded *0.020 inch* slotted PVC well screen, and packed in Ottawa sand to a height of 5 feet above the top of the well screen to prevent entrainment of sediment into the well during pumping. They were sealed with 2 feet of bentonite pellets and grouted with a 6:1 by dry weight mixture of Portland cement and bentonite powder to prevent leakage down into the well annulus from the surface. Each well was completed with a 4-inch steel security casing, and secured below ground in areas where traffic or aesthetic considerations required it. All wells were developed to ensure they were clear of sediment and foreign material introduced during drilling. Most well locations were selected in the presumed downgradient direction from the site(s), based on information available in the Phase I report, and always within the NoAFB boundary. Upgradient wells were located in two zones only (Zones 4 and 6) at the specific request of NoAFB for special long-term monitoring purposes.

3.1.1.3 Soil Borings

At sites where surface contaminant discharge was confirmed to have occurred directly onto the ground surface in the form of leaks or spills, WESTON proposed the use of soil borings to sample the surface soil. The top six or ten feet of soil were to be sampled at two sites (6 locations each) using a hollow-stem auger drill rig and the continuous split-spoon method to collect 2-foot vertical composite samples.

All soil borings and pilot holes for monitor wells were to be logged by a WESTON geologist following U.S. Air Force/USATHAMA procedures. During drilling activities, WESTON proposed monitoring the top of the hole and split-spoon samples for organic vapors and explosive gases, using an HNu and an explosimeter.

3.1.1.4 Elevation Surveys

To complete the hydrogeologic investigation, WESTON proposed to survey the elevations of all the monitor well casings with respect to existing benchmarks, and to make a complete round of groundwater level measurements. The purpose of gathering these data was for flow analysis, primarily to confirm the presumed direction of contaminant migration.

3.1.1.5 Groundwater Sampling

WESTON proposed sampling the 22 monitor wells to be installed, in a single round at least two weeks after well completion and development. All wells were to be purged of three well volumes immediately prior to sampling, using WESTON's Johnson-Keck Model SP-81 stainless steel submersible pump. Water samples were to be collected and preserved according to standard USEPA Groundwater Sampling protocols for the analytes of interest. Specific analytes for each zone are listed in Table 1-2, a summary of the analytical protocol for the proposed Field Program.

3.1.2 Zone- and Site-Specific Considerations

Specific factors affecting program development at a specific zone or site within a zone are reviewed in the following text.

3.1.2.1 Zone 1, Golf Course Waste Management Zone

Six of the twelve highest ranked sites in Table 1-1 are included in the Golf Course Waste Management Zone. For this

reason, a large portion of the Field Program was devoted to this Zone. The sites included in the zone are the following:

- Site No. 1, Industrial Waste Lagoons
- Site No. 3, Waste Pit No. 2
- Site No. 4, Waste Pit No. 1
- Site No. 5, Fire Protection Training Area No. 2
- Site No. 10, Landfill No. 1
- Site No. 12, Waste Pit No. 3

Specific actions were recommended for individual sites as described below:

- WESTON proposed a GPR survey in the vicinity of Site No. 1, the Industrial Waste Lagoons (now Ponds 1 and 2) to define the areal limits of the old lagoons and a somewhat more detailed survey to determine presence or absence of drum-like targets in the subsurface. A similar survey was proposed to locate Site No. 12, Waste Pit No. 3. The proposed surveys were not to be comprehensive enough to map exact locations of drum-like contacts, but merely to indicate whether or not a more comprehensive GPR survey of the lagoons would be necessary.

- WESTON proposed preliminary GPR surveys for the purpose of defining areal limits of the following sites: Waste Pit No. 2 in the southern end of the Golf Course Parking Lot (Site No.3); Waste Pit No. 1 (Site No. 4, now Pond 1); and Landfill No. 1 (Site No. 10).

- WESTON proposed collecting samples from three ponds: the Golf Course irrigation pond (Pond 1) on the approximate site of the old Waste Pit No. 1; and Ponds 2 and 3 on the approximate site of the old Industrial Waste Lagoons. Samples to be collected included bottom sediment at a single location in each pond, water samples from 1 foot off the bottom using a Kemmerer sampler, and fish tissue samples to be composited from several fish per pond. WESTON proposed using electroshock equipment or an equivalent method to obtain representative samples of the fish populations

in each pond, and to composite edible muscle tissue from these fish into a single sample per pond, to be analyzed for metals as listed in Table 1-2.

- WESTON proposed drilling six exploratory soil borings to total depths of six feet at Site No. 5, Fire Protection Training Area No. 2, in and around the perimeter of the burn area to determine the extent of soil contamination below this area.

In addition to these specific actions, WESTON proposed to install and sample a maximum of 9 monitor wells in order to monitor groundwater adjacent to the zone as a whole, in the presumed downgradient direction. MW-1 and MW-2 were to be located on Golf Course Drive immediately southwest from the old Industrial Waste Lagoons; MW-3 at the southern tip of the Golf Course parking lot, immediately south of Waste Pit No. 2, MW-4 adjacent to Waste Pit No. 1 (Pond 1); MW-5 through MW-7 along the southern Base boundary between Landfill No. 1 and the Santa Ana River Wash; MW-8 west of the Pistol Range between Waste Pit No. 3 and Landfill No. 1; and MW-9 along the southern boundary immediately adjacent to Fire Protection Training Area No. 2. Together, these nine wells form a semi-circle around the southwestern, southern and southeastern perimeter of the zone in the direction of regional groundwater flow (to the southwest) and along the Base boundary. Proposed well completion, surveying and sampling procedures for these wells followed the general considerations in section 3.11.

The proposed analytical protocol for samples to be collected from this Zone is reproduced in Table 3-2.

3.1.2.2 <u>Zone 2, Landfill Waste Management Zone</u>

The Landfill Waste Management Zone includes two of the twelve highest ranked sites in Table 1-1. These are:

- Site No. 2, Landfill No. 3

- Site No. 11, Fuel Sludge Disposal Area

WESTON proposed to install three monitor wells to monitor groundwater immediately adjacent to the sites in the presumed downgradient direction. These wells were to be approximately 60 feet deep and completed in the shallow

TABLE 3-2. PROPOSED GOLF COURSE WASTE MANAGEMENT ZONE SAMPLING PROTOCOL

SAMPLE NO.	TYPE[1]	TOC	TOX	VOA	METALS[2]	OIL & GREASE	CONDUCITIVTY	pH[3]	PHENOL	MEK	CYANIDE
MW-1	GW	X	X	X	X	X	X	X	X	X	
MW-2	GW	X	X	X	X	X	X	X	X	X	
MW-3	GW	X	X	X	X	X	X	X	X	X	
MW-4	GW	X	X	X	X	X	X	X	X	X	
MW-5	GW	X	X	X	X	X	X	X			
MW-6	GW	X	X	X	X	X	X	X			
MW-7	GW	X	X	X	X	X	X	X			
MW-8	GW	X	X	X	X	X	X	X	X		X
MW-9	GW	X	X	X	X	X	X	X			
TB-1:1-5	SS			X							
TB-2:1-5	SS			X							
TB-3:1-5	SS			X							
TB-4:1-5	SS			X							
TB-5:1-5	SS			X							
TB-6:1-5	SS			X							
POND 1-W	SW	X	X	X	X	X	X	X	X	X	
POND 1-S	BS			X					X	X	
POND 1-F	FT				X						
POND 2-W	SW	X	X	X	X	X	X	X	X	X	
POND 2-S	BS			X					X	X	
POND 2-F	FT				X						
POND 3-W	SW	X	X	X	X	X	X	X	X	X	
POND 3-S	BS			X					X	X	
POND 3-F	FT				X						

[1] GW= Groundwater, SS=Subsurface Soil, SW= Surface Water, BS= Bottom Sediment, FT=Fish Tissue Composite

[2] Metals analyses include Pb, Cr, N_1, Cd, As, Zn, Cu, Hg

[3] Determined in the field.

aquifer. Proposed well completion, surveying and sampling procedures for these wells followed the general considerations in Section 3.1.1.

3.1.2.3 Zone 3, Site No. 6, Underground Waste Oil Storage Tank

WESTON had originally anticipated drilling up to 8 soil exploratory soil borings approximately 20 feet deep at Site No. 6, in order to inspect subsurface soils for oil contamination. However, during the Pre-Survey Site Inspection, it was noted that Building 647 had been demolished and that the area of the buried waste fuel tank was undergoing conversion for expansion of the Base Exchange Service Station. It is presently unknown whether or not the tank was removed or repaired for further service. The presence of additional buried tanks and pipes in the area made excessive exploratory drilling in the area hazardous, not only to facilities but also to personnel.

WESTON proposed to construct a single monitor well in a downgradient position from the fuel tank location with the final location to be selected during consultation with the construction supervisor from Base Civil Engineering. Proposed well depth was 60 feet. Proposed well completion, surveying and sampling procedures for this well followed the general considerations in Section 3.1.1.

3.1.2.4 Zone 4, IWTP Waste Management Zone

The IWTP Waste Management Zone includes the following sites:

- Site No. 7, IWTP Sludge Drying Beds
- Site No. 13, IWTP Sludge Disposal Area
- Site No. 17, Drummed Waste Storage Area No. 3 and Waste Fuel and Solvent Sump
- (Unranked) IWTP Discharge Ditch

WESTON proposed a limited soil exploratory boring program for the IWTP Waste Management Zone, along with installation of a single monitor well. Six soil borings were to be drilled in the Drummed Waste Storage Area No. 3, in such a way that the fuel and solvent sump would be encircled on three sides. Proposed procedures followed the general

considerations in Section 3.1.1, and 2-foot composite soil samples were retained for analysis of VOA and phenol.

WESTON originally proposed to drill one downgradient monitor well at the IWTP Waste Management Zone. At the request of NoAFB, USAF OEHL authorized installation of a total of 4 monitor wells in this zone, one in the presumed upgradient direction, three in the presumed downgradient direction. Proposed procedures followed the general considerations in Section 3.1.1.

3.1.2.5 Zone 5, Site No. 14, Waste Pit No. 4

WESTON proposed drilling a single monitor well adjacent to this site in the presumed downgradient direction, with the final location to be determined in consultation with Base Civil Engineering to ensure that buried facilities would be avoided. Proposed procedures followed the general considerations in Section 3.1.1.

3.1.2.6 Zone 6, Site No. 16, AAVS/DAVA Evaporation Ponds

This site was not included in the Phase II Pre-Survey Report because it had not been recommended for further investigation in the Phase I Report (ESI, 1982). It was included in a modification of the Task Order (Appendix B) following a request made by NoAFB and authorized by USAF OEHL. In response to this request, WESTON proposed to install 4 monitor wells, one in the presumed upgradient direction, three in the presumed downgradient direction (based upon information available in the Phase I Report). Proposed procedures for monitor well installation, construction and sampling followed the general considerations in Section 3.1.1.

3.1.3 Results

The results of the field program were carefully analyzed as they were generated, subjected to Quality Control review, and incorporated into the remaining field investigations. This analysis is documented in this report, for the purpose of confirming the absence or presence of an environmental contamination problem at each of the investigated sites. These results have also been used to develop recommendations for further investigation in the Quantification Stage of the Phase II effort. These recommendations, summarized in Section 6 of this report, are specifically tailored to

support Concept Engineering Evaluation of Remedial Action Alternatives.

3.2 FIELD INVESTIGATION

A field investigation has been conducted to define the hydrologic and geologic setting at Norton AFB, and to determine the possible presence of hazardous environmental contaminants that may have resulted from past product storage and handling practices or waste disposal operations at the Base.

A Ground Penetrating Radar (GPR) Survey was conducted to help define the areal extent of five sites in the Golf Course Waste Management Zone. Soil borings were used at two sites to confirm the presence or absence of contamination in subsurface soils. A total of 22 monitor wells were installed. Data gathered from these wells included descriptions of subsurface stratigraphy, moisture content, and evidence of contamination during drilling, as well as measurements of water levels and casing elevation surveys for the purposes of groundwater flow analysis. A round of groundwater samples was collected from all 22 wells to evaluate the impact of the six Zones on groundwater quality in the vicinity of NoAFB. In addition, samples of surface water, bottom sediment, and fish tissue were collected from three ponds in the Golf Course Waste Management Zone, potentially impacted by past disposal activities in that Zone. The field work has been summarized on a Zone-by-Zone basis in Table 3-1.

3.2.1 Schedule of Activities

The field investigation at Norton AFB began on 3 November 1983 and was completed on 31 July 1984. Table 3-3 is a summary of WESTON's field activities schedule at Norton AFB.

3.2.2 Ground Penetrating Radar Survey

A Ground Penetrating Radar (GPR) Survey was conducted in Zone 1, on the Norton AFB Golf Course, between 19 September and 23 September 1983. The major effort of the survey was concentrated around the following sites, shown in Figure 3-1.:

- o Site 1: Industrial Waste Lagoon
- o Site 3: Waste Pit No. 2

TABLE 3-3

FIELD ACTIVITY SCHEDULE

Date	
3 November - 12 December 1983	Drilling rig on-site. Soil borings and soil sampling at IWTP and at Fire Protection Training Area No. 2. Installation of monitor wells 1-15 at Zones 1 - 5.
12 - 31 May 1984	Drilling rig on site. Installation of monitor wells 16-22 at Zones 4 and 6.
5 - 13 July 1984	Monitor well sampling. Sampling of surface water and bottom sediment for Ponds 1-3. Survey of well elevations, locations and depth-to-water measurements.
30 - 31 July 1984	Sampling of fish from Ponds 1-3.

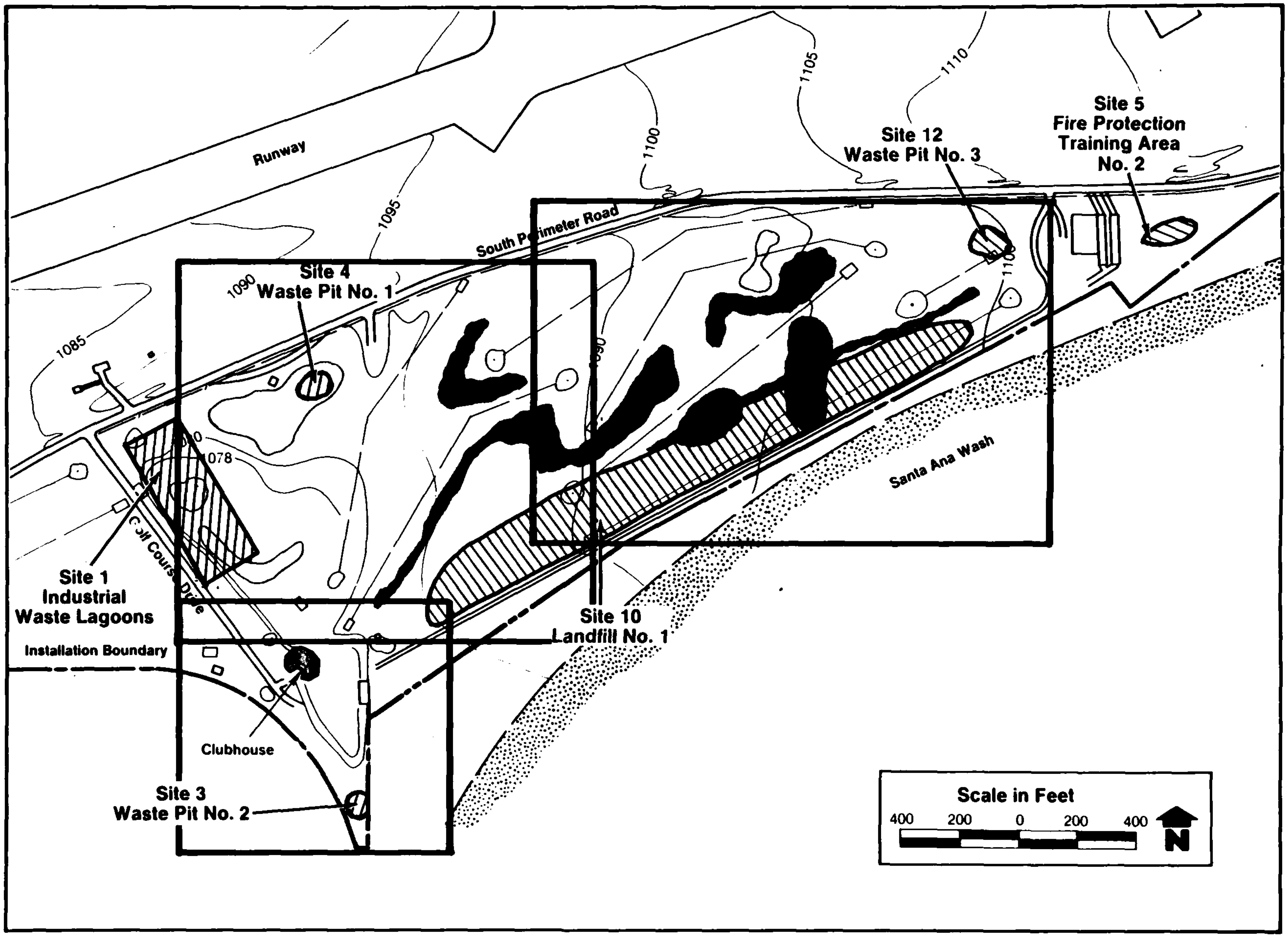


FIGURE 3-1 INDEX MAP OF GPR SURVEY SITES IN ZONE 1, GOLF COURSE WASTE MANAGEMENT ZONE

Site 4: Waste Pit No. 1
Site 10: Landfill No. 1
Site 12: Waste Pit No. 3

The survey began at Site 12 (Waste Pit No. 3) with a depth calibration of the GPR instrument over a culvert of known diameter and depth. Thereafter, traverses were run across the site with the Radar Receiver/Transmitter (T/R) antenna to detect changes in the subsoils and buried objected. Since the exact location of the sites suspected of being buried beneath the Golf Course was not known, the survey was conducted in grid fashion.

3.1.2.1 Objective of the GPR Survey

The objective of the GPR survey was to characterize, insofar as possible, at the level of a confirmation study, subsurface conditions relative to the type of disposal activity conducted at the site. More specifically, the survey objectives were as follows:

- To define the areal extent of the industrial waste lagoons and to verify the presence or absence of drum-like targets at Site No. 1.
- To define the areal extent of the waste pits at Sites Nos. 3 and 4.
- To define the areal extents of the landfill at Site No. 10.
- To define the areal extent of the waste pit and to determine the presence or absence of drum-like targets at Site No. 12.

3.2.2.2 GPR Survey Metholodogy

The GPR survey of the Golf Course was conducted by WESTON using a GSSI System 8 Ground Penetrating Radar (GPR) unit. The general site boundaries were established from information derived from a chronological examination of areal photographs and information referenced in the Phase I Report. To expedite the survey, the radar unit was mounted in a Cushman gasoline-operated golf cart, and the R/T

antenna towed from behind. The product of the GPR survey was a series of real-time radar profiles. Radar signal enhancement and subsequent profile quality was achieved through various micro-processing techniques. Prior to conducting the survey, the Radar system was calibrated against the physical and chemical characteristics of the soils underlying the Golf Course. Surveying began on 19 September at Site 12. Traverses were conducted over the site in grid fashion. Grid dimensions were determined by the degree of area details desired.

3.2.2.3 GPR Survey Analysis

Analysis of GPR survey data involved an individual interpretation of each profile and then a collective comparison of the results. The interpretation process had two objectives:

- Apply specific knowledge of known signature densities and configurations to the identification of pipes, drums, trenches, soil structures, discontinuities and surface disturbances.

- Identify trends and conditions by comparing standard profiles one to another. This process identified continuity in stratified soil interfaces, buried utilities and groundwater data.

The GPR profiles produced as a result of this survey exhibited good resolution, defining variations in soil characteristics and pinpointing individual targets beneath the golf course.

3.2.3 Drilling Program

The field program at NoAFB included completion of 12 soil borings to an average depth of 8 feet, and installation of 22 monitor wells to an average depth of 60 feet. The drilling was performed in two stages: November-December 1983, and May 1984. All drilling work was performed by the drilling crews of Stang Hydronics, Inc. of Rancho Cordova and Orange, California, under the direct supervision of an on-site WESTON geologist. The drilling rig used was a truck-mounted Mobile Drill hollow-stem auger boring rig.

3.2.3.1 Soil Borings

Each soil boring was advanced using a hollow-stem auger, and sampled continuously with 2-inch diameter, 18 and 24 inch long split-spoon sampler following standard penetration test (SPT) procedures (ASTM Test D-1586). Exceptions to continuous split-spoon sampling occurred in soil zones with a high percentage of cobbles. The split-spoon sampler could not be driven in these cobble zones, and in some cases the rig had to be pulled off the hole, offset to a new position and the hole redrilled.

During drilling and sampling, boring logs of each hole were prepared, and have been included in Appendix D. Samples to be preserved for chemical analysis were transferred to glass jars, taking care to preserve sample integrity. Soil sampling procedures are summarized in Appendix F.

To prevent cross-contamination between soil samples, the split-spoon sampler was thoroughly washed in an Alconox detergent solution and rinsed with tap water after each sampling interval.

Upon completion of sampling, each boring was backfilled with drill cuttings from the hole.

3.2.3.2 Soil Vapor Monitoring

During all soil boring and well drilling operations, a Mine Safety Appliance (MSA) Explosimeter and an HNu Model No. PI-101 organic vapor photoionization detector (PID) were used to monitor explosive gases and organic vapors emanating from both the borehole and from soil samples. Soil samples were measured by transferring the soil to a glass jar approximately 3/4 full, capping it for approximately 1 minute, then uncapping the jar and inserting the probe in the headspace. These instruments were used for personnel safety, to identify unsafe working conditions and required levels of respiratory protection, and as field screening devices for organic contamination.

The HNu portable photoionization detection unit operates on the principle of detection based on light-induced ionization of carbon-carbon or carbon-nitrogen double or triple bonds (alkenes, alkynes, nitrites, amines and aromatics). It is particularly suited to the detection of volatile aromatic compounds such as benzene, toluene, ethylbenzene, xylenes

and chlorobenzenes. It is "blind" to those non-photoionizable, volatile substances such as saturated alcohols, saturated amines, alkanes and saturated fluorochlorocarbons. It is capable of detecting airborne hydrocarbons at the one parts per million level. Prior to field use, it is calibrated in the laboratory against a set of hexane standards, so that readings obtained are measured with respect to hexane. For this reason, it is used to measure qualitative or relative degree of atmosphere contamination with organics. In the field, it is zeroed against ambient background atmospheric levels.

The explosimeter is an MSA combustible gas and oxygen deficiency meter. Oxygen levels are expressed as percent (%) oxygen in the atmosphere (21.5% is normal), while combustible gas levels are expressed as a percentage of the Lower Explosive Limit (LEL) of pentane. The instrument is used primarily as a safety tool to monitor the working atmosphere for potentially explosive conditions.

3.2.3.3 Monitor Well Construction

Each pilot boring was advanced with a truck-mounted drill rig employing hollow-stem auger techniques. Soils in all pilot borings were sampled at 5-foot intervals, with a 2-inch diameter, 18-inch long split-spoon sampler using Standard Penetration Test (SPT) Techniques as specified by ASTM Standard Method No. D-1586. All soil samples collected were transferred to glass jars and have been retained in archives at the WESTON Office in West Chester, Pennsylvania. During each sampling operation, an HNu Model PI-101 organic vapor photoionization detector was used to detect any organic vapors emanating from the borehole or from the split-spoon samples. Well logs, including lithologic descriptions and results of HNu measurements, have been included along with well completion summaries in Appendix E.

Monitor wells were installed inside the hollow-stem auger flights before they were pulled from the hole. Each monitor well was constructed of threaded 2-inch diameter Schedule 40 Polyvinylchloride (PVC) pipe with No. 20 (0.020-inch) machined slotted PVC screen. Most of the wells were completed using 20 feet of screen. The presence of confining soils and/or cobble zones dictated the use of shorter screens in a few of the wells.

Well screens were sand packed in medium-grained Ottawa sand from the bottom of the hole to 3 feet above the top of the

screen. A thick bentonite slurry, poured into the annular space between the auger flights and the well casing, was used to form a seal approximately 2-feet thick over the sand pack. A Portland Cement-bentonite grout mixture was poured into the annular space to complete the surface seal as the auger flights were withdrawn from the borehole. All monitor wells were secured by enclosing the riser pipe in a protective iron casing with a locking cap. The protector casings in Wells MW-1 through MW-9 and MW-14 through MW-22 were installed below ground surface and over-fitted with a Brooks cast cement vault, countersunk nearly flush with ground surface. Typical well construction diagrams for the two types of wells completed are shown in Figure 3-2. Well completion summaries for all monitor wells have been included in Appendix E. A summary of monitor well construction details is given in Table 3-4.

Each well was developed by airlift methods using an Ingersoll-Rand Model G85 compressor, fitted with a half-inch PVC pipe, inserted down the inside of the riser pipe into the screened section. Groundwater was continuously airlifted until the effluent was sand-free and clear to the satisfaction of the on-site WESTON geologist. Minimum development time was one hour, and averaged approximately two hours per monitor well.

Following the completion of each well, drill cuttings were removed to a location designated by NoAFB, and the general area restored as closely as possible to pre-drilling conditions.

3.2.3.4 Zone 1, Golf Course Waste Management Zone

A total of six soil borings and nine monitor wells were drilled in this Zone in November-December 1983. The soil borings were drilled at Site No. 5, Fire Protection Training Area No. 2. Soil boring locations, shown in Figure 3-3, were selected so that they would surround the perimeter of the burn site. Each boring penetrated to a depth of six feet below ground surface, and was continuously sampled with a split-spoon. The predominant soil type encountered was ash produced in training exercises. Samples were retained for analysis of VOA and phenol. Organic vapor concentrations emanating from soil samples were monitored with an HNu meter, and explosimeter levels were measured in-hole with a portable meter. Results of field measurements and a complete discussion of subsurface conditions is presented in Section 4 of this report.

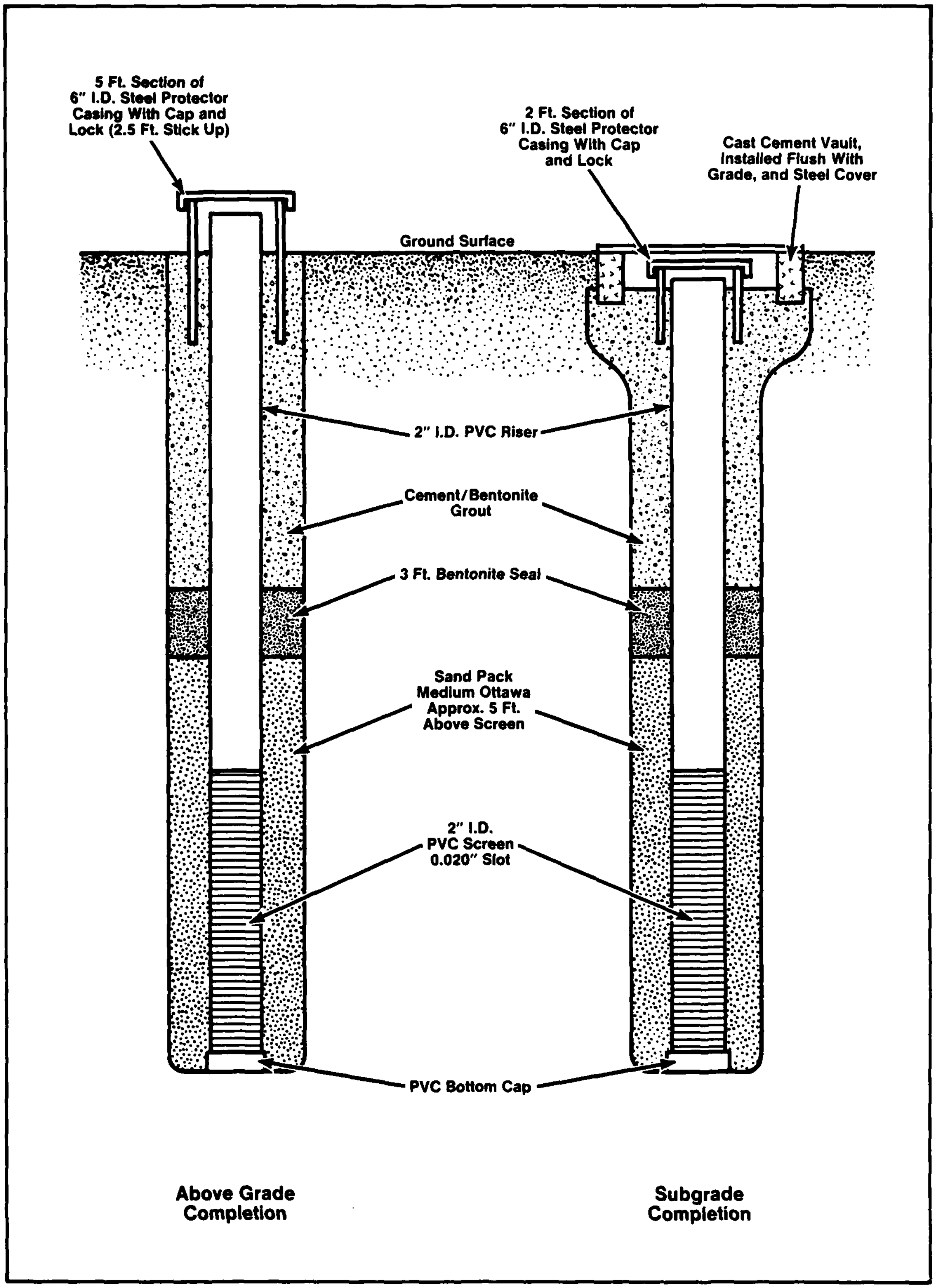


FIGURE 3-2 TYPICAL MONITOR WELL CONSTRUCTIONS

TABLE 3-4 SUMMARY OF WELL CONSTRUCTION DETAILS, NORTON AFB

Well Number	Approximate Ground Surface Elevation (in feet)	Top of PVC Casing Elevation (in feet)	Screened Interval Below Ground Surface (in feet)	Sandpacked Interval Below Ground Surface (in feet)	Predominant Lithology in Screened Zone
MW-1	1084.7	1084.05	25 -45	20-46	f-c SAND, Tr Gravel, Tr-S Silt.
MW-2	1082.4	1081.72	69.5-89.5	64-89.5	f-c SAND, Silty Sand, Sandy Silt, Tr f-Gravel
MW-3	1079.9	1082.15	7.5-27.5	5-31	f-c SAND, Sandy Silt, S f-Gravel
MW-4	1080.9	1080.39	50.5-60.5	45-65	f-c SAND, Silty Sand, Tr f-Gravel
MW-5	1081.1	1080.56	39 -59	34-59	m-c SAND, Silty Sand, Tr f-Gravel
MW-6	1096.1	1095.10	35 -55	30-55	f-m SAND, Silty Sand, Silt, Tr Clay
MW-7	1096.3	1095.75	49 -59	44-59	f-c SAND, Silty Sand, Sandy Silt, S f-c Gravel
MW-8	1099.0	1098.52	40 -60	32-60	f-c SAND, f-c Gravel, Silty Sand
MW-9	1106.8	1108.75	39 -59	34-59	f-c SAND, Silt, Tr f-Gravel
MW-10	1061.7	1064.40	10 -30	5-30	f-c SAND, Silty Sand, Tr f-Gravel
MW-11	1163.4	1165.84	36 -56	30-61	f-c SAND, Silty Sand, Sandy Silt, Tr f-Gravel
MW-12	1170.7	1172.36	40 -60	35-61	f-c SAND, Tr f-Gravel, Tr Silt
MW-13	1178.7	1181.47	39 -59	29-59	f-c SAND, Silty Sand, Tr f-Gravel
MW-14	1064.7	1064.18	47.5-67.5	40-67.5	f-c SAND, Tr f-c Gravel, Tr Silt
MW-15	1084.5	1084.15	42 -50	40-50	m-c SAND, Tr f-c Gravel, Tr f-Sand, Tr Silt
MW-16	1163.0	1162.54	33 -53	28-53	f-c SAND, Tr f-c Gravel, Tr Silt, Tr Clay
MW-17	1163.7	1163.24	37 -57	32-57	f-c SAND, Tr f-Gravel, Tr Silt
MW-18	1165.1	1164.63	37 -57	32-57	f-c SAND, Tr f-Gravel, Tr Silt
MW-19	1165.9	1165.38	35 -55	30-55	f-c GRAVEL, f-c Sand, Tr Silt
MW-20	1060.4	1059.87	10 -30	6-30	f-c SAND, Sandy Silt, f-c Gravel, Tr Clay
MW-21	1060.3	1059.83	12 -32	7-32	f-m SAND, Silty Sand, Sandy Silt, Tr f-Gravel, Tr c-Sand
MW-22	1068.9	1068.42	19 -39	15-39	f-c SAND, Silt, Silty Sand, Tr f-Gravel

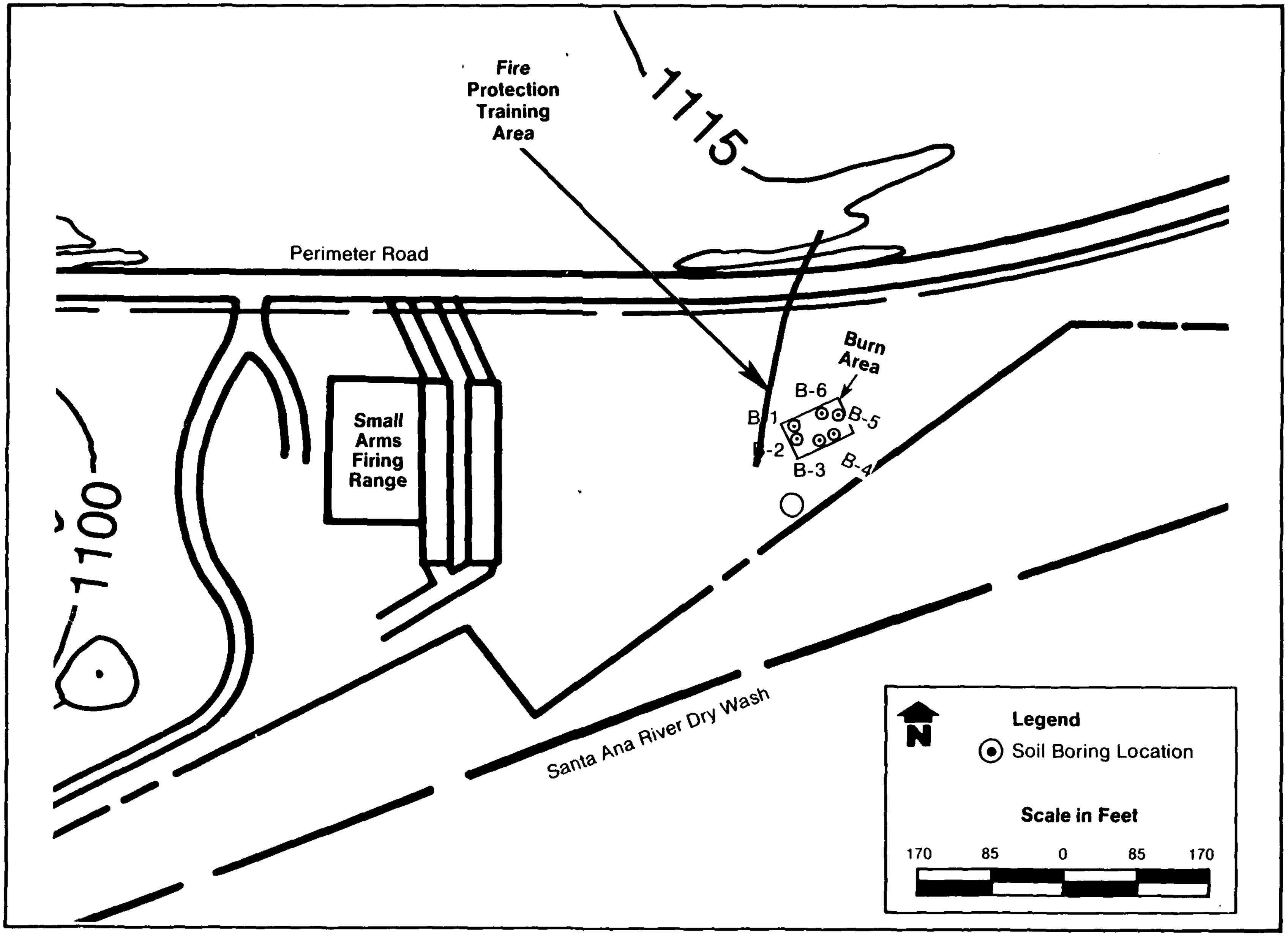


FIGURE 3-3 SOIL BORING LOCATIONS AT SITE NO. 5, FIRE TRAINING AREA NO. 2

AD-A162 365 INSTALLATION RESTORATION PROGRAM (IRP) PHASE II STAGE 1 - PROBLEM CONFIRM..(U) WESTON (ROY F) INC WEST CHESTER PA JUL 85 F33615-80-D-4006 2/2

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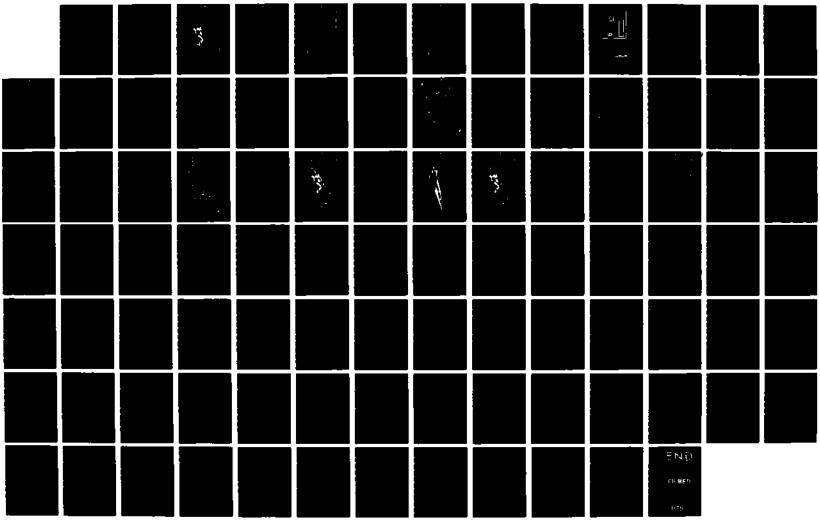

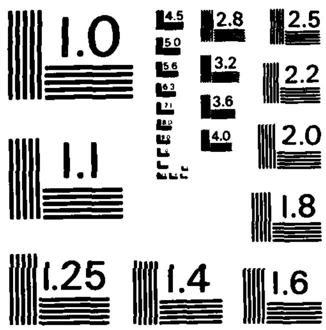

MICROCOPY RESOLUTION TEST CHART
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The nine monitor wells were installed south and southeast of the zone, along the Base boundary and in the presumed downgradient direction from sites in the Zone (the Industrial Waste Lagoon, Landfill No. 1, Waste Pits Nos. 1, 2 and 3, Fire Protection Training Area No. 2). Locations of monitor wells MW-1 through MW-9 are shown in Figure 3-4. The average depth of these wells was approximately 57 feet and ranged between 27.5 and 89.5 feet. Typical sediments encountered included silt, silty sand, sand, and some gravel/cobble zones. Screen depths and lengths were determined by the types of soils encountered and by groundwater elevations observed during drilling operations. A monitor well construction summary for the Golf Course Waste Management Zone is included in Figure 3-5. A complete discussion of subsurface conditions encountered is presented in Section 4 of this report.

3.2.3.4 Zone 2, Landfill Waste Management Zone

Three monitor wells (MW-11, MW-12 and MW-13) were installed in this Zone, in locations estimated in the field to be hydrogeologically downgradient from the two sites (Landfill No. 2 and the Fuel Sludge Disposal Area). These locations are shown on Figure 3-6.

Typical sediments encountered consisted of silt, silty sand, sand and gravel, and included cobble zones. Screen depths and lengths were determined from groundwater elevation and types of soils penetrated during drilling operations. A monitor well construction summary for wells in this Zone and Zone 6 is included in Figure 3-7. A complete discussion of subsurface conditions encountered in this zone is provided in Section 4.

3.2.3.5 Zone 3, Underground Waste Oil Storage Tanks

A single monitor well (MW-15) was installed in December 1983, adjacent to and in a presumed downgradient direction from Site No. 6, the Underground Waste Oil Storage Tank (Figure 3-8). This monitor well was drilled to a depth of 50 feet. Typical sediments encountered included silt, sand, and some gravel and cobble zones. The well was completed with 8 feet of screen between 42 and 50 feet below ground surface. A monitor well completion summary is provided in Figure 3-9. Moderate organic vapor levels were measured on the HNu between depths of 39 and 50 feet. A complete

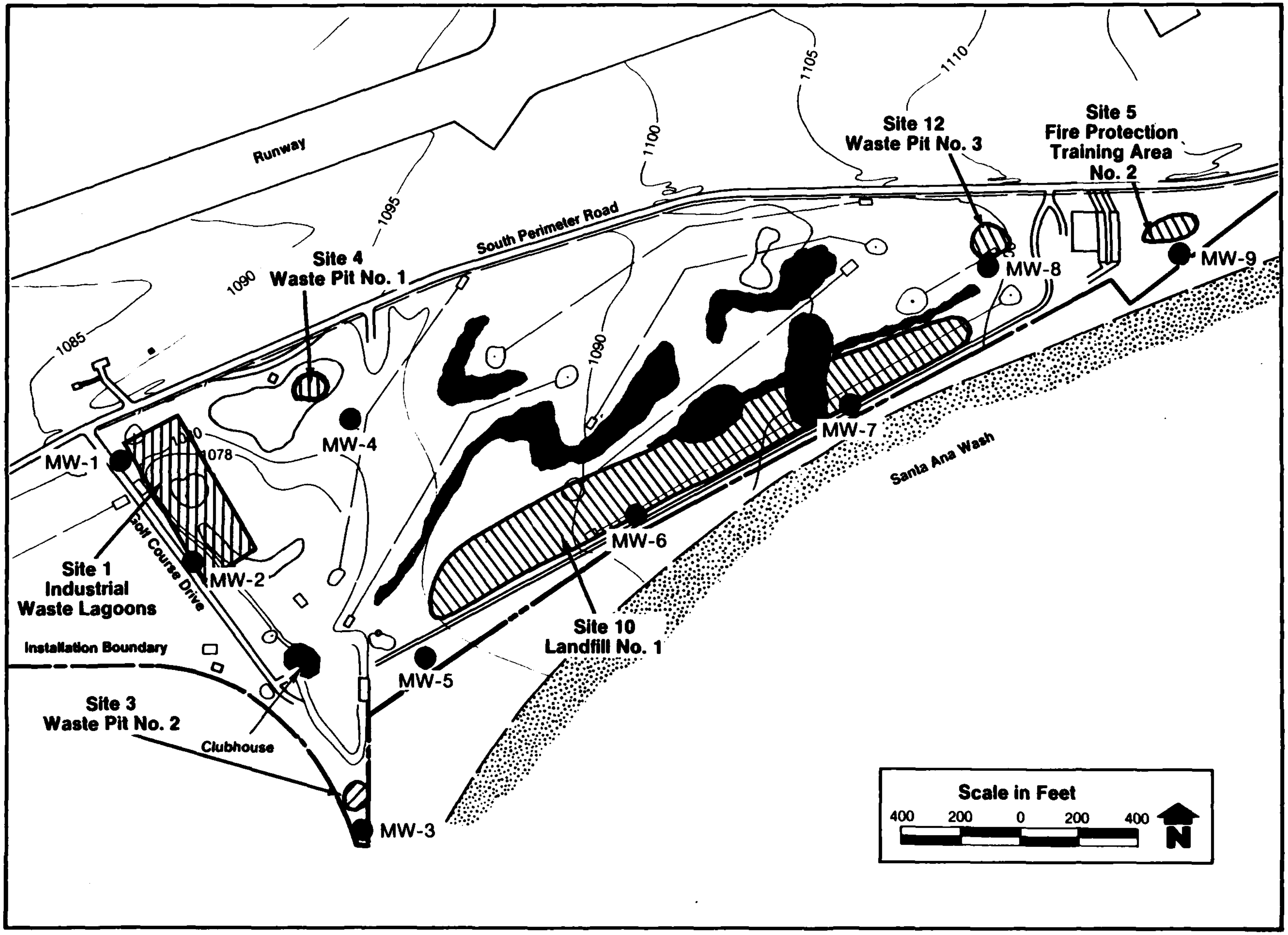

FIGURE 3-4 MONITOR WELL LOCATIONS IN ZONE 1, GOLF COURSE WASTE MANAGEMENT ZONE

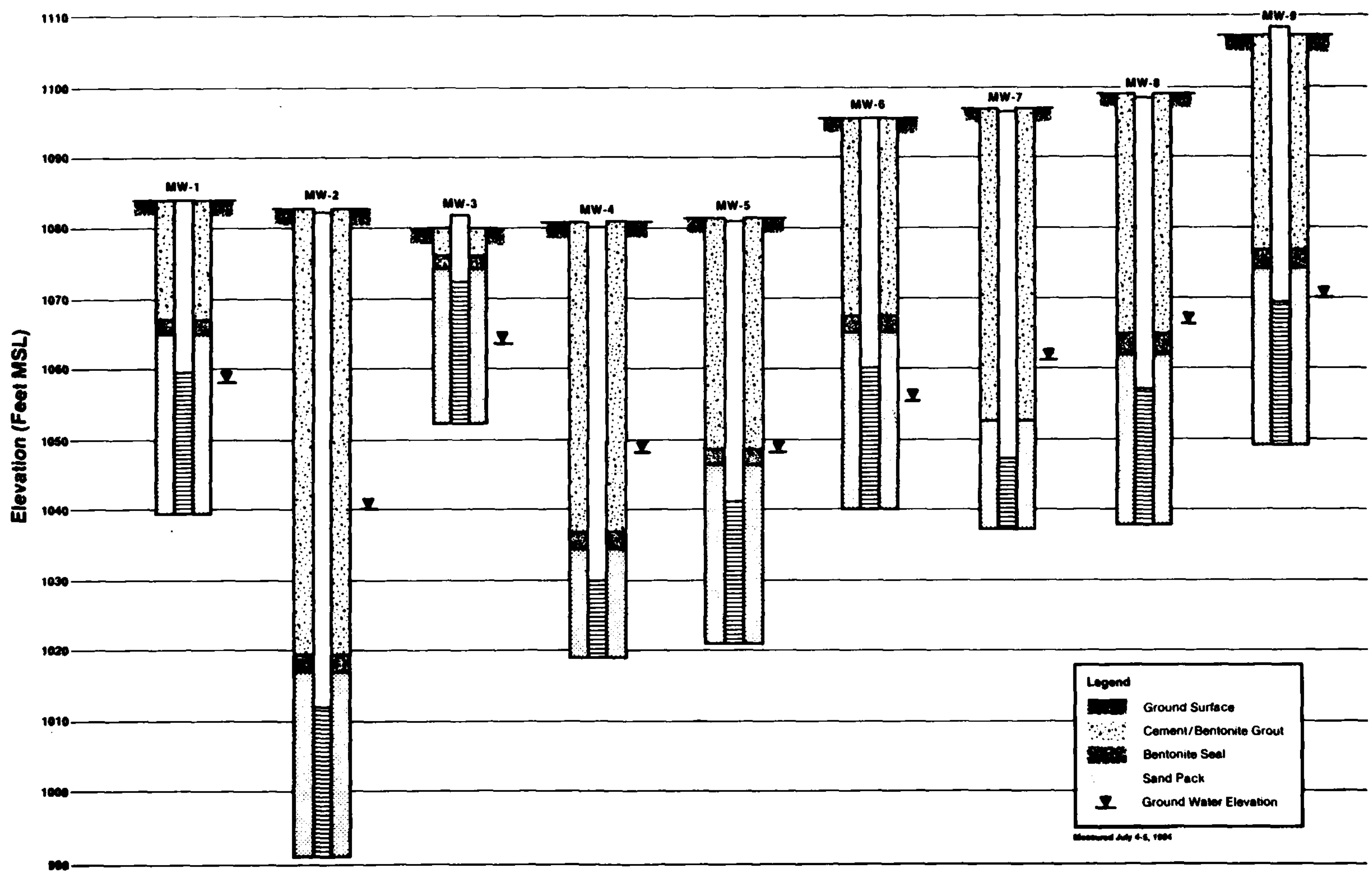

FIGURE 3-5 WELL CONSTRUCTION SUMMARY, ZONE 1, MW-1 THROUGH MW-9

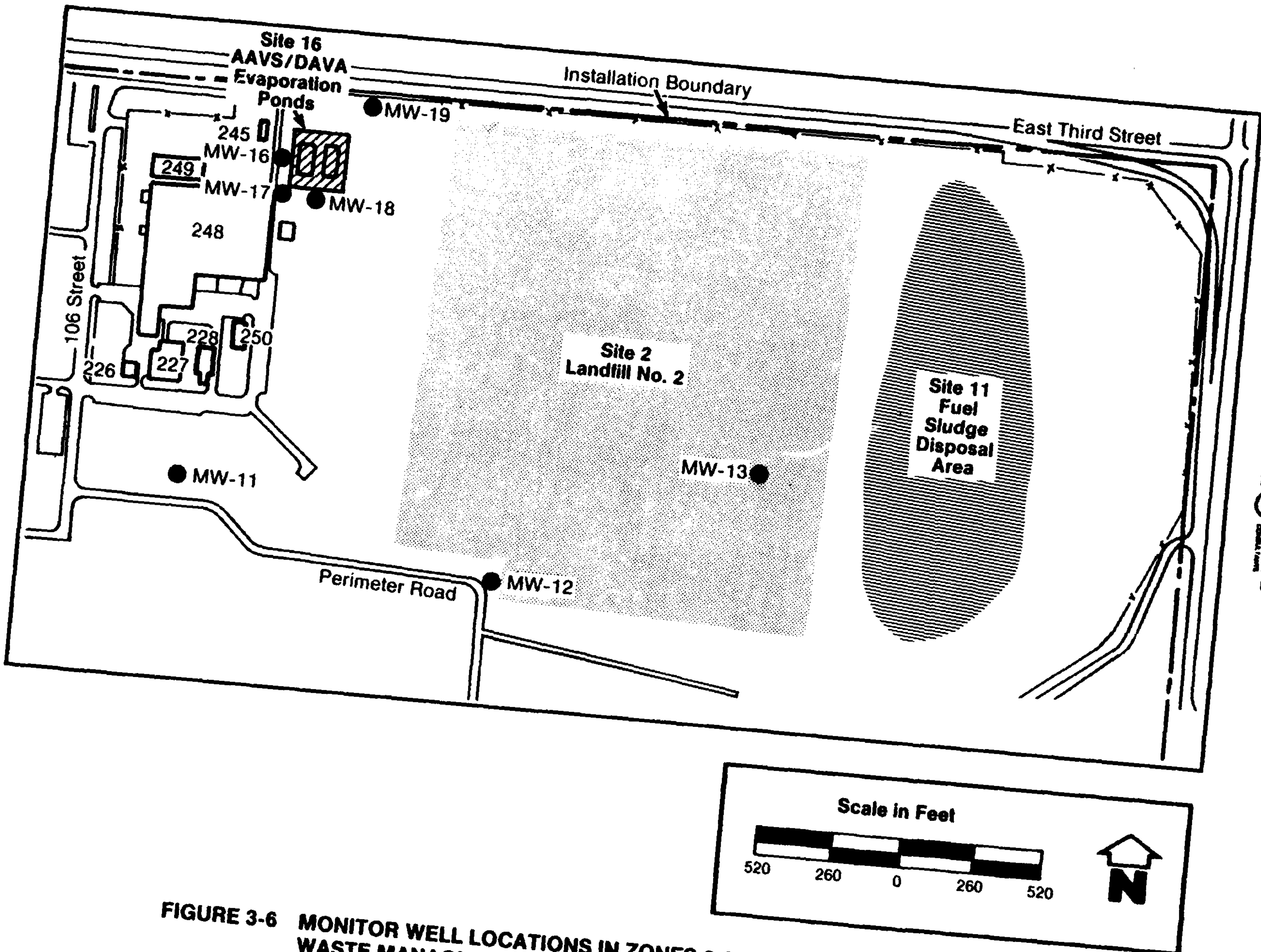

FIGURE 3-6 MONITOR WELL LOCATIONS IN ZONES 2 AND 6, LANDFILL WASTE MANAGEMENT ZONE AND AAVS/DAVA EVAPORATION BASINS

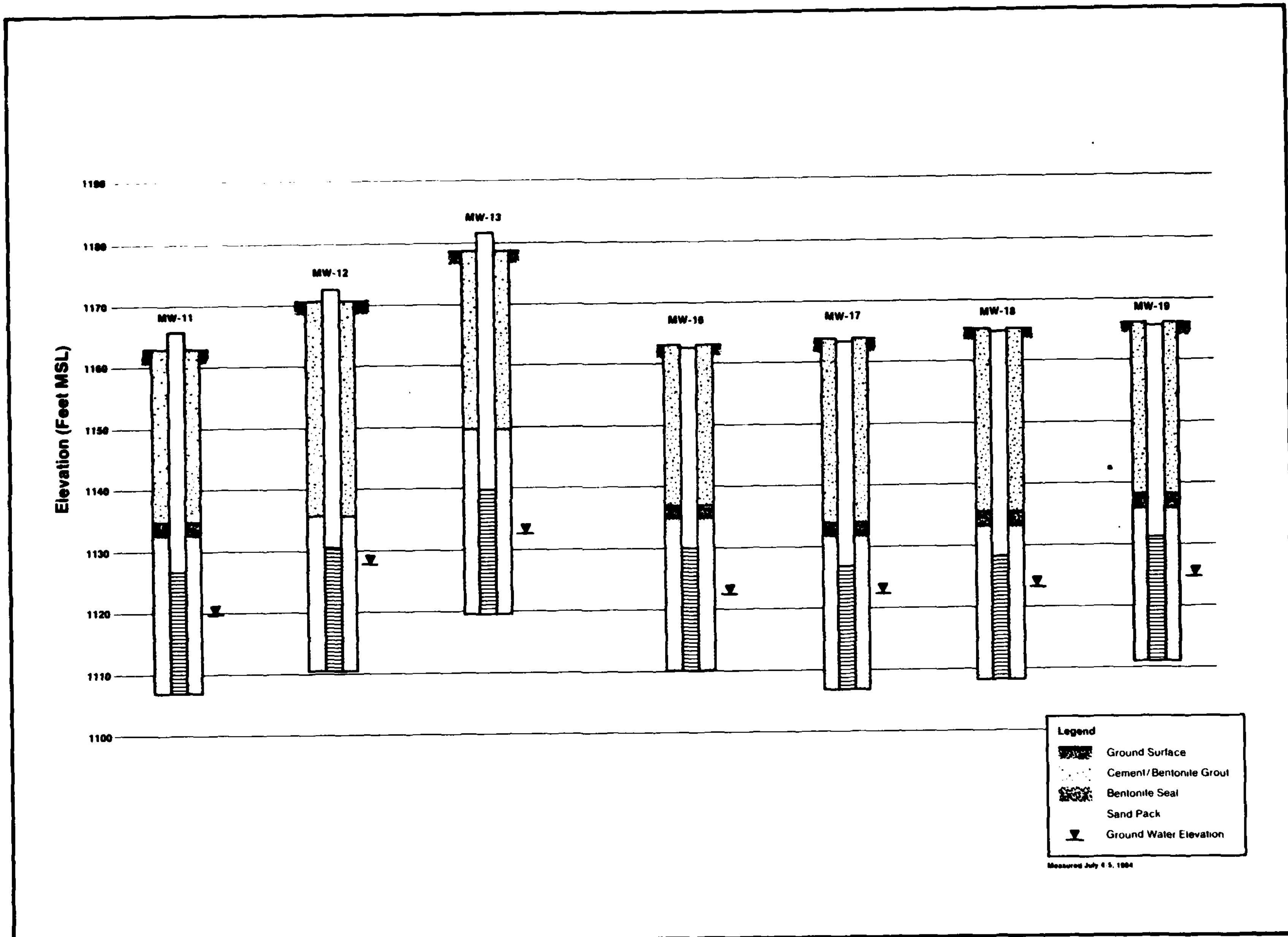

FIGURE 3-7 WELL CONSTRUCTION SUMMARY, ZONES 2 AND 6, MW-11 THROUGH MW-13 AND MW-16 THROUGH MW-19

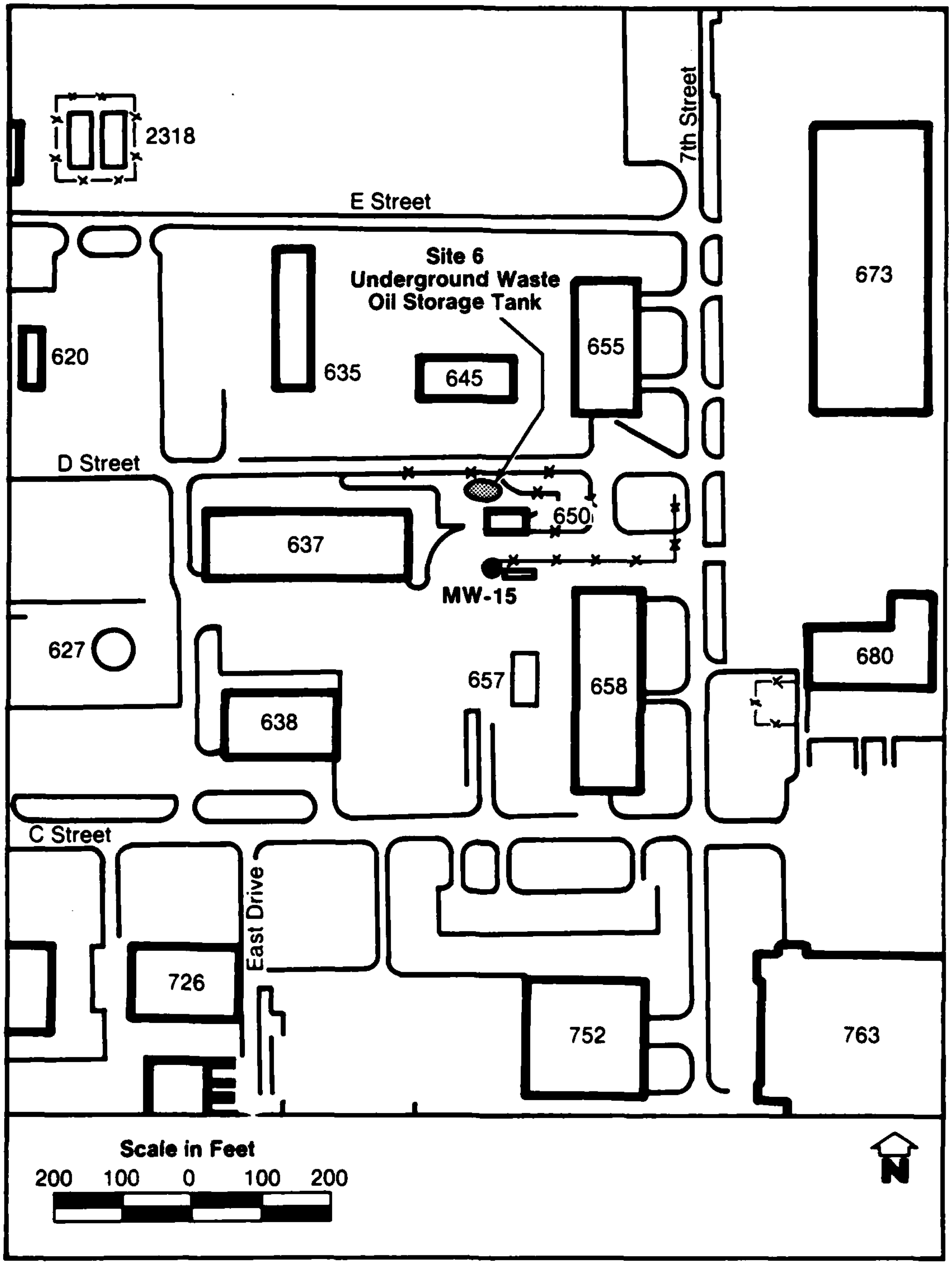

FIGURE 3-8 MONITOR WELL LOCATION AT ZONE 3, UNDERGROUND WASTE OIL STORAGE TANK

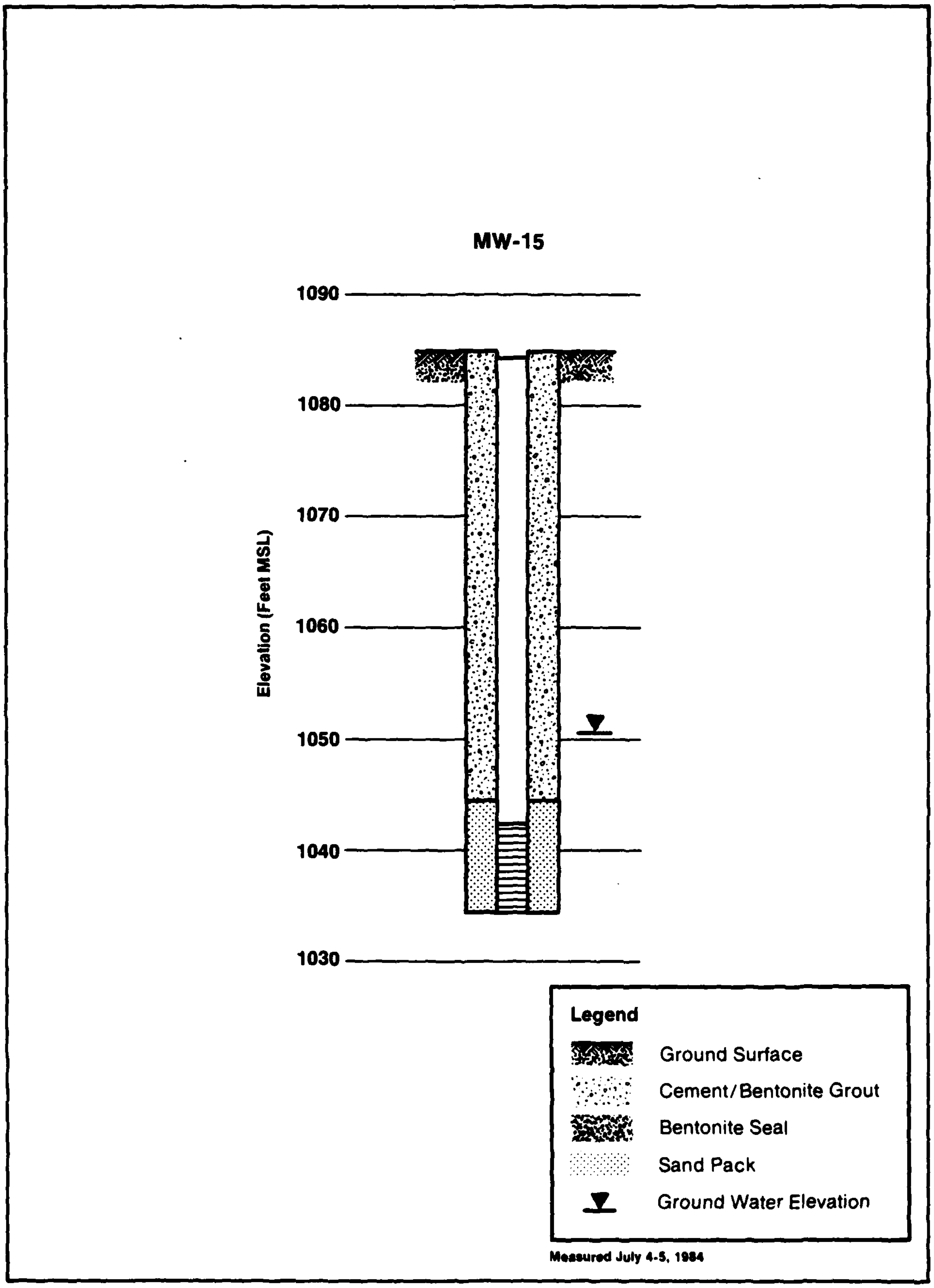

FIGURE 3-9 WELL CONSTRUCTION SUMMARY, ZONE 3, MW-15

discussion of subsurface conditions at this site is included in Section 4.

3.2.3.7 Zone 4, IWTP Waste Management Zone

A total of six borings and four monitor wells were installed in this Zone. The six soil borings were drilled in the Drummed Waste Storage Area (Site No. 17) around the perimeter of the Waste Fuel and Solvent Sumps, at the locations shown on Figure 3-10. Each boring was drilled to a depth of approximately 10 feet, and sampled continuously by the split-spoon method. Samples were retained for analysis of VOA and phenol. Elevated levels of organic vapors were detected with the HNu at one of the borings, and respirators were worn by on-site personnel.

One monitor well (MW-10) was drilled in December 1983 in the presumed downgradient direction from the Sludge Drying Beds. In response to a request by NoAFB, three additional monitor wells were installed in the IWTP Zone, two more in the presumed downgradient direction (MW-20 and MW-21) and one in the presumed upgradient direction (MW-22). Locations of all 4 monitor wells are shown in Figure 3-11. Monitor wells were drilled to depths of between 30 and 39 feet, and were completed with 20 feet of screen. A monitor well completion summary for all 4 wells in Zone 4 is provided in Figure 3-12. The predominant sediment type encountered was sand with minor amounts of silty sand. A complete discussion of subsurface conditions is presented in Section 4.

3.2.3.8 Zone 5, Waste Pit No. 4

A single monitor well (MW-14) was installed adjacent to and in the presumed downgradient direction from Waste Pit No. 4 in November 1983 at the location shown in Figure 3-13. The well was drilled to a depth of 67.5 feet and completed with 20 feet of PVC screen. A monitor well completion summary is provided in Figure 3-14. Typical sediments encountered were silts, silty sands, sands and zones of gravel and cobbles. A complete discussion of subsurface conditions is provided in Section 4.

3.2.3.9 Zone 6, AAVS/DAVA Evaporation Basins

Four monitoring wells (MW-16 through MW-19) were drilled in this Zone in May 1984, at locations shown in Figure 3-6. MW-19 was drilled in the presumed upgradient direction, the other three in the presumed downgradient direction from the two evaporation basins. The wells were drilled to depths

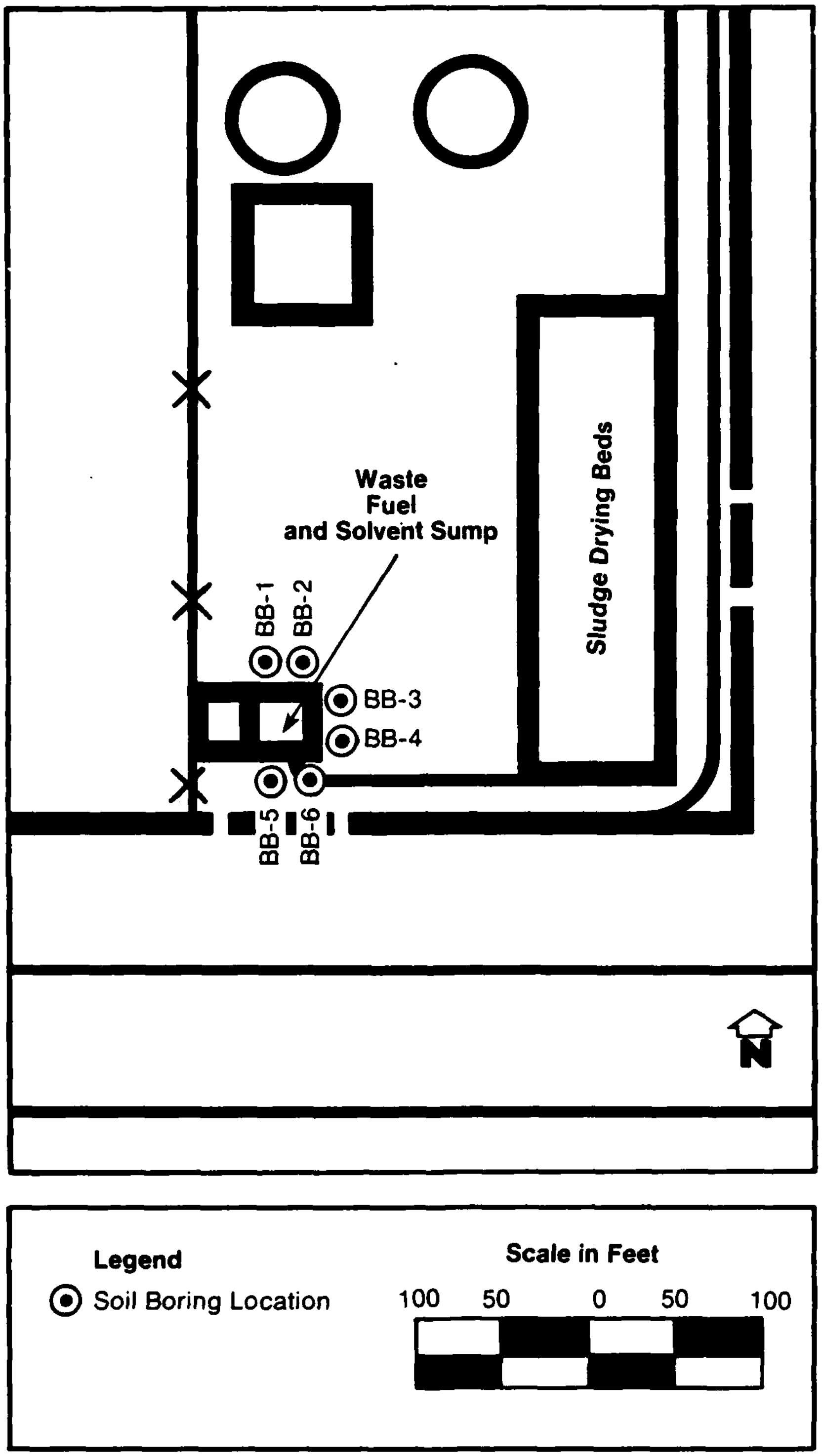

FIGURE 3-10 SOIL BORING LOCATIONS AT SITE NO. 17, DRUMMED WASTE STORAGE AREA

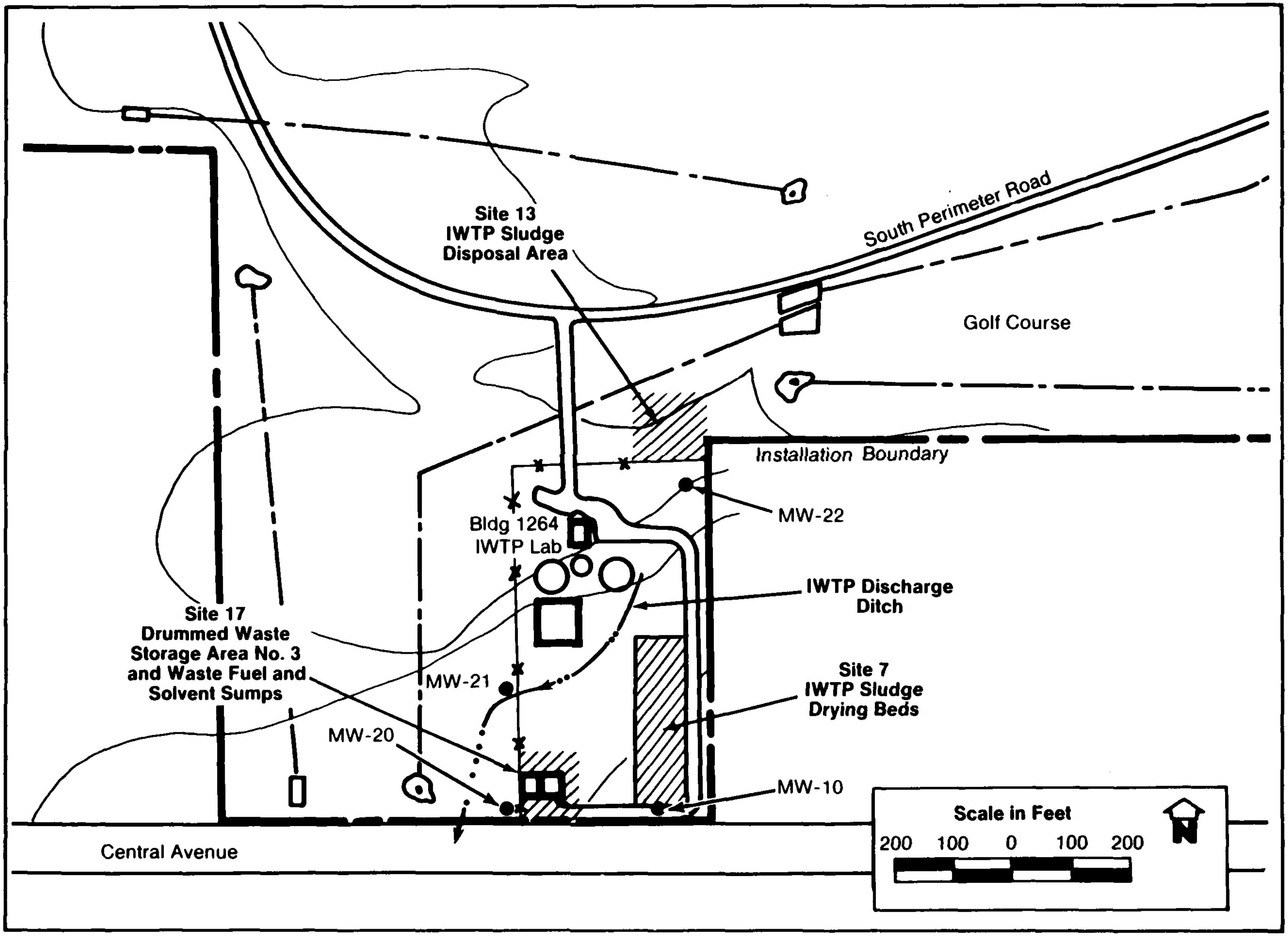

FIGURE 3-11 MONITOR WELL LOCATIONS AT ZONE 4, IWTP WASTE MANAGEMENT ZONE

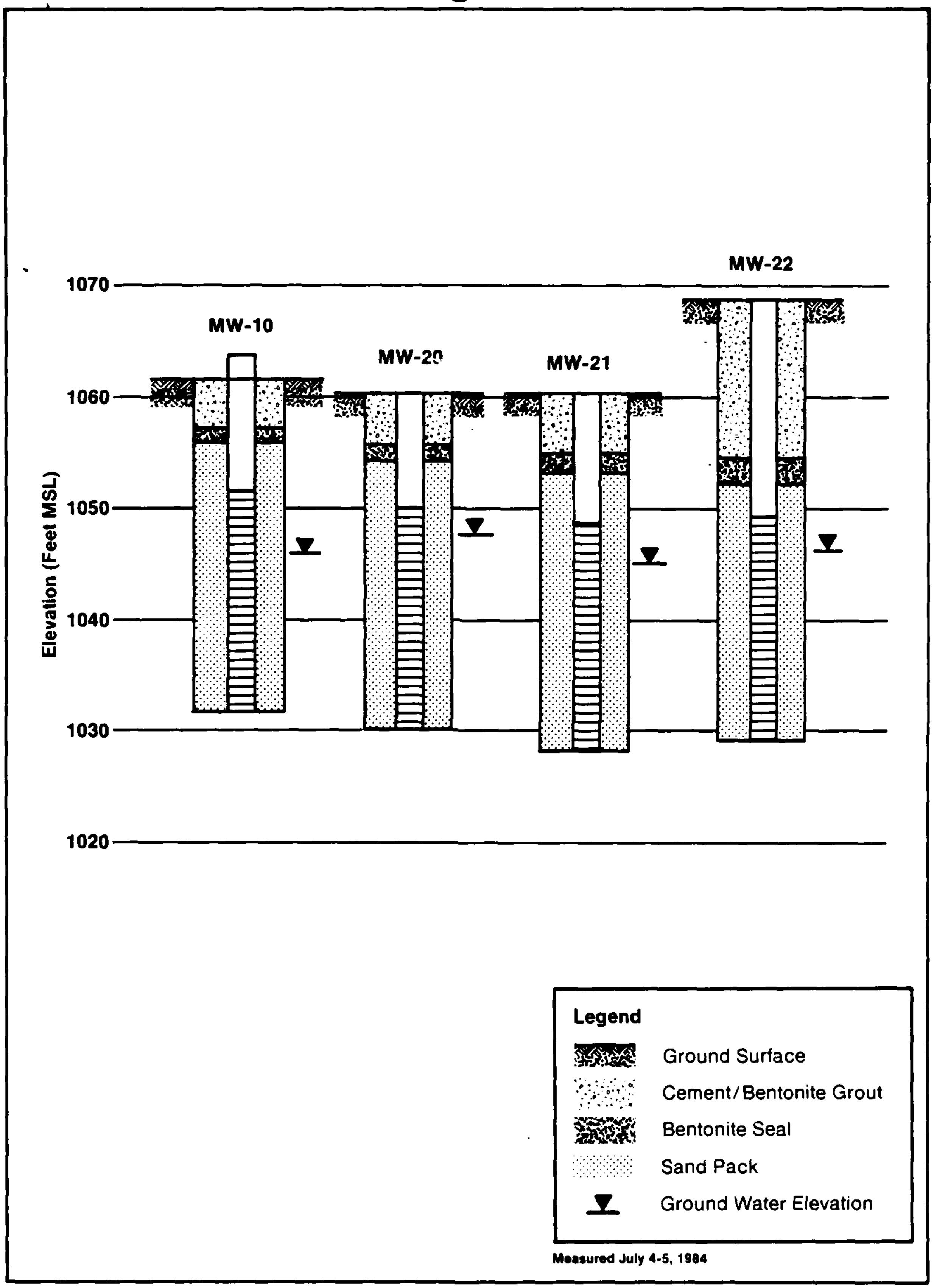

FIGURE 3-12 WELL CONSTRUCTION SUMMARY, ZONE 4, MW-10 AND MW-20 THROUGH MW-22

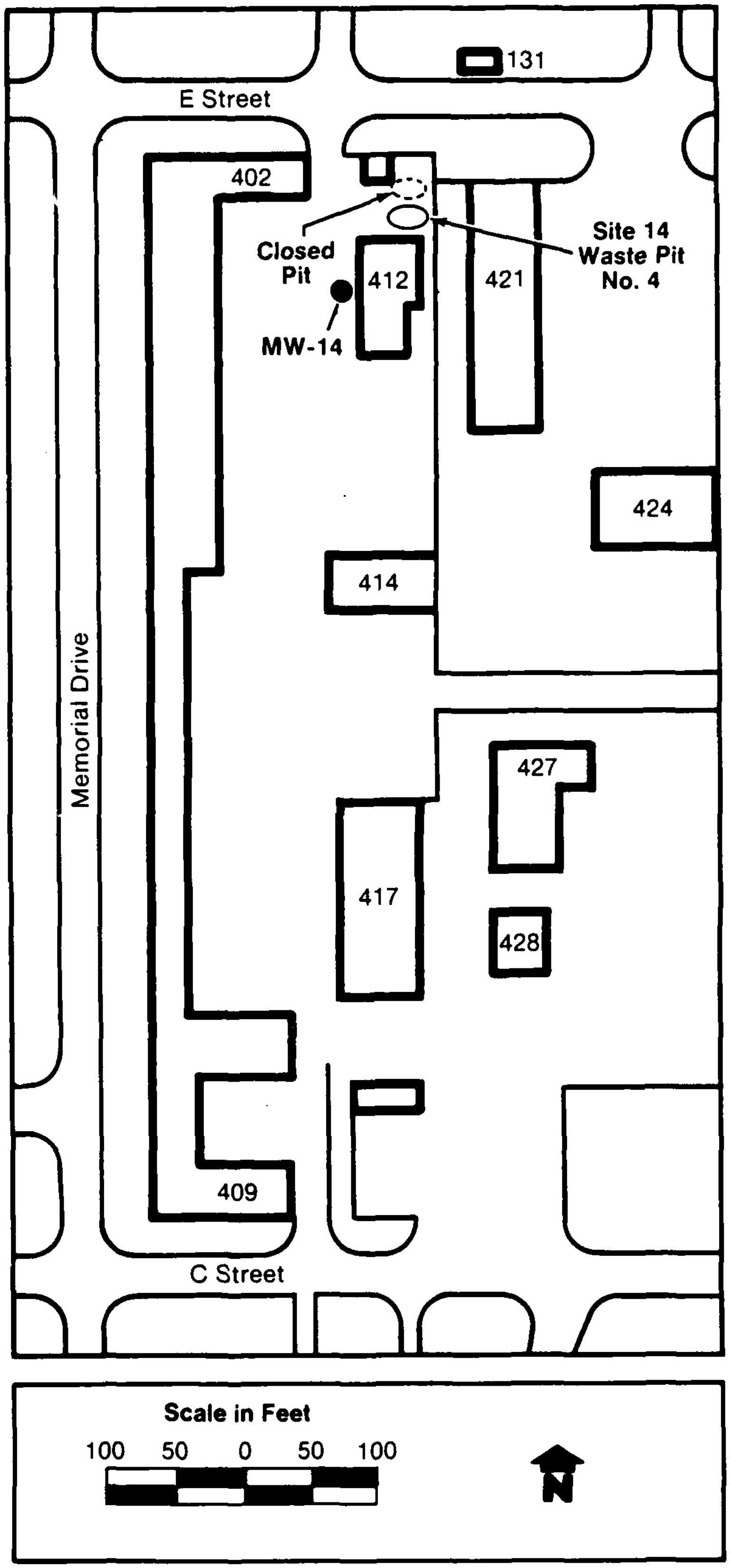

FIGURE 3-13 MONITOR WELL LOCATION AT ZONE 5, SITE 14, WASTE PIT NO. 4

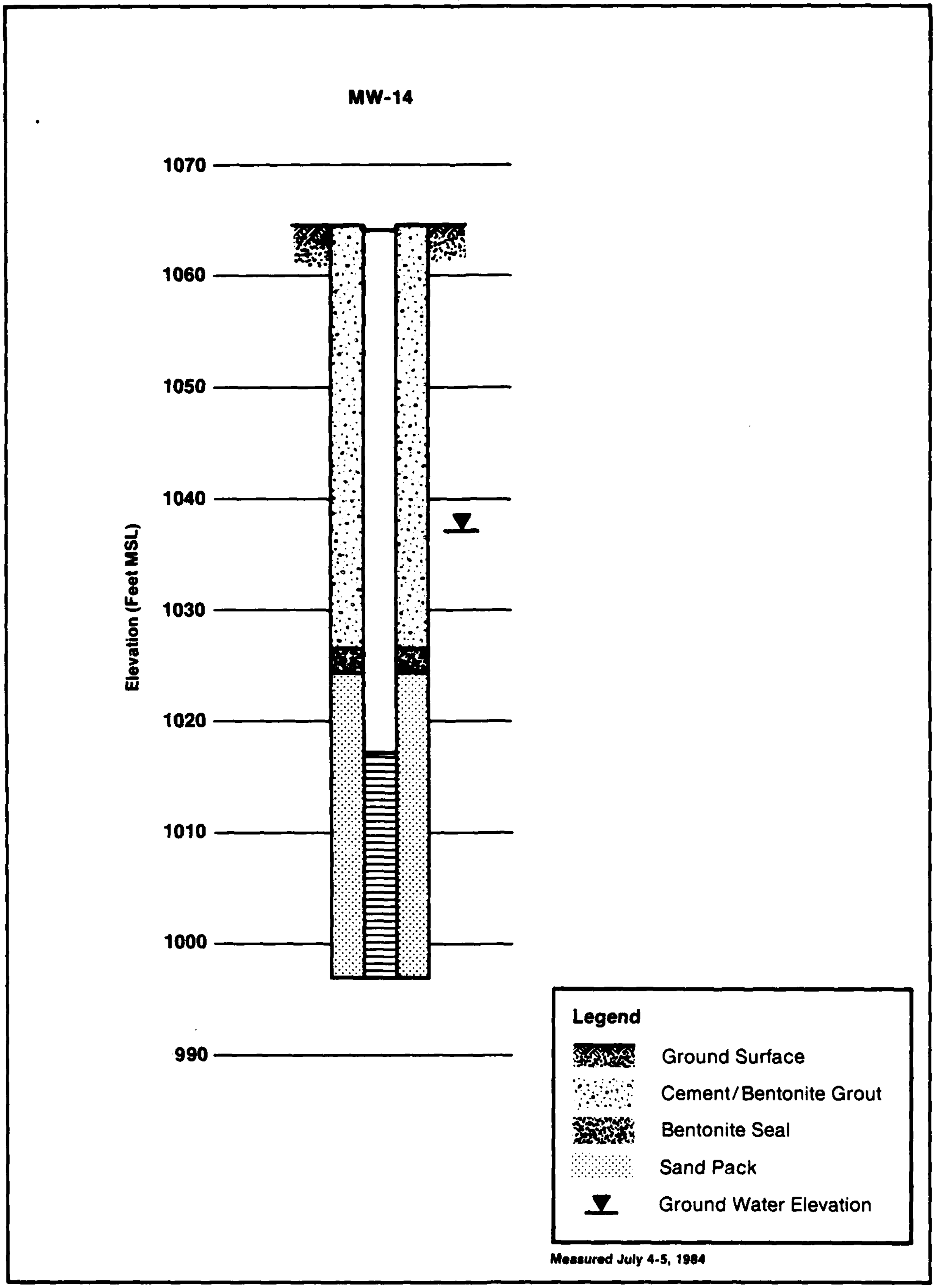

FIGURE 3-14 WELL CONSTRUCTION SUMMARY, ZONE 5, MW -14

between 53 and 57 feet and completed with 20 feet of screen. The typical sediment encountered was sand with some gravel and cobble zones. A monitor well summary diagram for the AAVS/DAVA wells as well as the Zone 2 wells is provided in Figure 3-7. A complete discussion of subsurface conditions is provided in Section 4.

3.2.4 Field Testing and Sampling Program

Additional field testing and sampling tasks were performed by WESTON in July and November 1984. This field program included a survey of groundwater elevations, field testing of ground and surface water, and collection of groundwater, surface water, bottom sediment and fish tissue samples for laboratory analysis.

3.2.4.1 Groundwater Elevation Surveying

An engineer's level was used to survey the elevation of the tops of the PVC well casings on all 22 wells. Top-of-casing elevations were surveyed relative to Mean Sea Level (msl), using two benchmarks on the Base boundary with known elevations referenced to the U.S. Geodetic Vertical Datum. Elevations were surveyed to the nearest 0.01 feet, with an estimated error of $\pm$ .02 feet.

A complete round of groundwater level measurements was taken on July 5 and 6, 1984. All measurements were referenced to the top of the PVC casing, using an Olympic Electrical water level probe.

Between the time of groundwater level measurement and well sampling, it was discovered that the PVC casing in MW-7 had been damaged during emplacement of the steel protective casing. In order to be able to sample this well in a manner consistent with the others, the upper portion of the PVC casing had to be replaced. Well rehabilitation was performed by Stang Hydronics, Inc., on 12 July 1984, using a backhoe to excavate and rebuild the upper 5 feet of the well. The elevation of the new PVC casing was re-surveyed on 13 July 1984 by WESTON personnel.

Table 3-5 lists the surveyed elevation of the top of PVC casing, as well as measured depths to water and calculated water level elevations for each well.

TABLE 3-5

SUMMARY OF MONITOR WELL ELEVATION SURVEY

JULY 5-6, 1984

Zone	Well	Depth to Water (in feet) July 5-6, 1984	Elevation of Top of Casing (feet above MSL)	Groundwater Level Elevation (in feet)
1. Golf Course Waste Management Zone	1	25.53	1084.05	1058.52
	2	41.50	1081.72	1040.22
	3	18.40	1082.15	1063.75
	4	32.66	1080.39	1047.73
	5	32.37	1080.56	1048.19
	6	39.75	1095.10	1055.35
	7	34.39	1095.75[1]	1061.36
	8	32.87	1098.52	1065.65
	9	38.62	1108.75	1070.13
2. Landfill Waste Management Zone	11	45.83	1165.84	1120.01
	12	44.78	1172.36	1127.58
	13	48.96	1181.47	1132.51
3. Underground Waste Oil Storage Tank	15	33.50	1084.15	1050.65
4. IWTP Waste Management Zone	10	18.47	1064.40	1045.93
	20	12.30	1059.87	1047.57
	21	14.57	1059.83	1045.26
	22	22.62	1068.42	1045.80
5. Waste Pit No. 4	14	27.12	1064.18	1037.06
6. AAVS/DAVA Evaporation Basin	16	40.15	1162.54	1122.39
	17	40.86	1163.24	1122.38
	18	41.59	1164.63	1123.04
	19	40.87	1165.38	1124.51

[1]Changed to 1095.84 on July 12, 1984

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3.2.4.2 Field Testing for Water Quality

During collection of all groundwater and surface water samples for laboratory analysis, grab samples from each location were gathered for field measurement of pH and specific conductance (SC). These samples were measured within 3 hours of collection, using a VWR Model No. 55 pH meter and a YSI Model No. 32 SC meter. The results of these measurements are summarized for groundwater in Table 3-6 and for surface water in Table 3-7.

3.2.4.3 Groundwater Sampling

Groundwater samples were collected from 22 monitor wells between 5 and 13 July 1984. In November 1984 the monitor wells were resampled for oil and grease, and MW-22 for TOC. Samples from each well were collected in appropriate containers and preserved for analysis of corresponding constituents following the protocol in Table 1-2 and procedures outlined in Section 3.1.1.5 above. The portion of the sample to be analyzed for metals was filtered in the field before preservation through an 0.45 micron millipore filter, using a vacuum pump.

In order to accomplish groundwater sampling efficiently and to ensure adequate field quality control, specific procedures were developed for groundwater sampling at Norton AFB and are described in Appendix F, the Site Sampling and QA/QC Plan. These procedures address well purging, sample collection and preservation, collection of quality control samples, and chain-of-custody documentation. Field sample log sheets are shown in Appendix G and chain-of-custody forms are reproduced in Appendix H. Standard laboratory analysis protocols used in the analysis of these samples are provided in Appendix I.

3.2.4.4. Pond Sampling

Pond sampling was accomplished on 6-8 July and 30-31 July 1984, and involved collection of single samples of bottom sediment, surface water, and fish tissue from three Golf Course Ponds. Pond 1, the Golf Course irrigation pond, is located on the site of the old Waste Pit No. 1 (Site No. 4). It is lined with concrete and was patched with bentonite after it was found to be leaking. It is approximately 10 feet deep in the center and 1.5 acres in area. It is used to store drinking water from the Base supply system and feeds the Golf Course irrigation system. Ponds 2 and 3 are located approximately on the site of the old Industrial

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TABLE 3-6

SUMMARY OF FIELD TESTED WATER QUALITY PARAMETERS

(GROUND WATER)

Zone	Well	pH	Specific Conductance (umhos/cm)
1. Golf Course Waste Management Zone	1	6.81	674
	2	7.17	510
	3	7.81	1480
	4	7.21	514
	5	7.11	584
	6	7.41	814
	7	7.30	659
	8	7.27	500
	9	7.26	684
2. Landfill Waste Management Zone	11	6.88	342
	12	6.97	251
	13	6.94	365
3. Underground Waste Oil Storage Tank	15	7.02	1177
4. IWTP Waste Management Zone	10	7.01	525
	20	7.24	464
	21	7.40	366
	22	6.87	802
5. Waste Pit No. 4	14	6.75	1053
6. AAVS/DAVA Evaporation Basins	16	6.53	1637
	17	6.65	782
	18	6.59	627
	19	6.47	423

TABLE 3-7

SUMMARY OF FIELD TESTED WATER QUALITY PARAMETERS

(SURFACE WATER)

Zone	Location	pH	Specific Conductance (umhos/cm)
1. Golf Course Waste Management Zone	Pond 1	8.15	260
	Pond 2	9.10	814
	Pond 3	9.22	376

Waste Lagoons (Site No. 1). Pond 2 has a slightly higher elevation than Pond 3, and water from Pond 2 flows into Pond 3 either directly or as seepage through a small marshy area between the two ponds. They are unlined, occupy a combined area of approximately 0.5 acres, and are both 2 to 3 feet deep.

Pond sampling procedures were developed for the Field Sampling and QA/QC Plan in Appendix F, but had to be amended somewhat due to the depth and the presence of a concrete lining in Pond 1. Pond sampling locations are shown in Figure 3-15.

Pond water samples were collected first, using a Kemmerer sampler, lowered to approximately one foot from the pond bottom near the center of the pond. Due to the shallow depths of Ponds 2 and 3, samples from these ponds were collected directly into glass containers by lowering them from the side of a boat. Water samples were transferred into appropriate containers and preserved for the required analytes following the analytical protocol in Table 3-3. The portion of a sample to be preserved for analysis of metals was filtered through a 0.45 micron millipore filter. Sample labelling, storage, shipping and chain-of-custody followed the same procedures developed for groundwater samples (Appendix E).

Bottom sediment samples were collected from Ponds 2 and 3 using a brass core sampler with a PVC-insert. Due to the presence of a cement liner, a sample of bottom sediment could not be obtained by this method in Pond 1. Therefore, a clean shovel and a stainless steel spatula were used to collect sediment from the shore of the pond immediately below the water level. Sediment samples were transferred to glass vials with Teflon septum caps, and amber glass bottles with Telfon-lined lids for the analysis of VOA (including MEK) and phenol, following requirements listed in Table 3-2.

Several fish were collected from each pond, using a weighted, 25 foot long seine net. Approximately half of each of Pond 2 and Pond 3 were dragged with the net, and a representative sample of the fish population was obtained from each of these ponds. The only species found in Pond 2F was bluegill, including young of the year, ranging in length from 15 to 35 millimeters (mm) and older (2-3 years) individuals ranging in length from 90 to 150 mm.

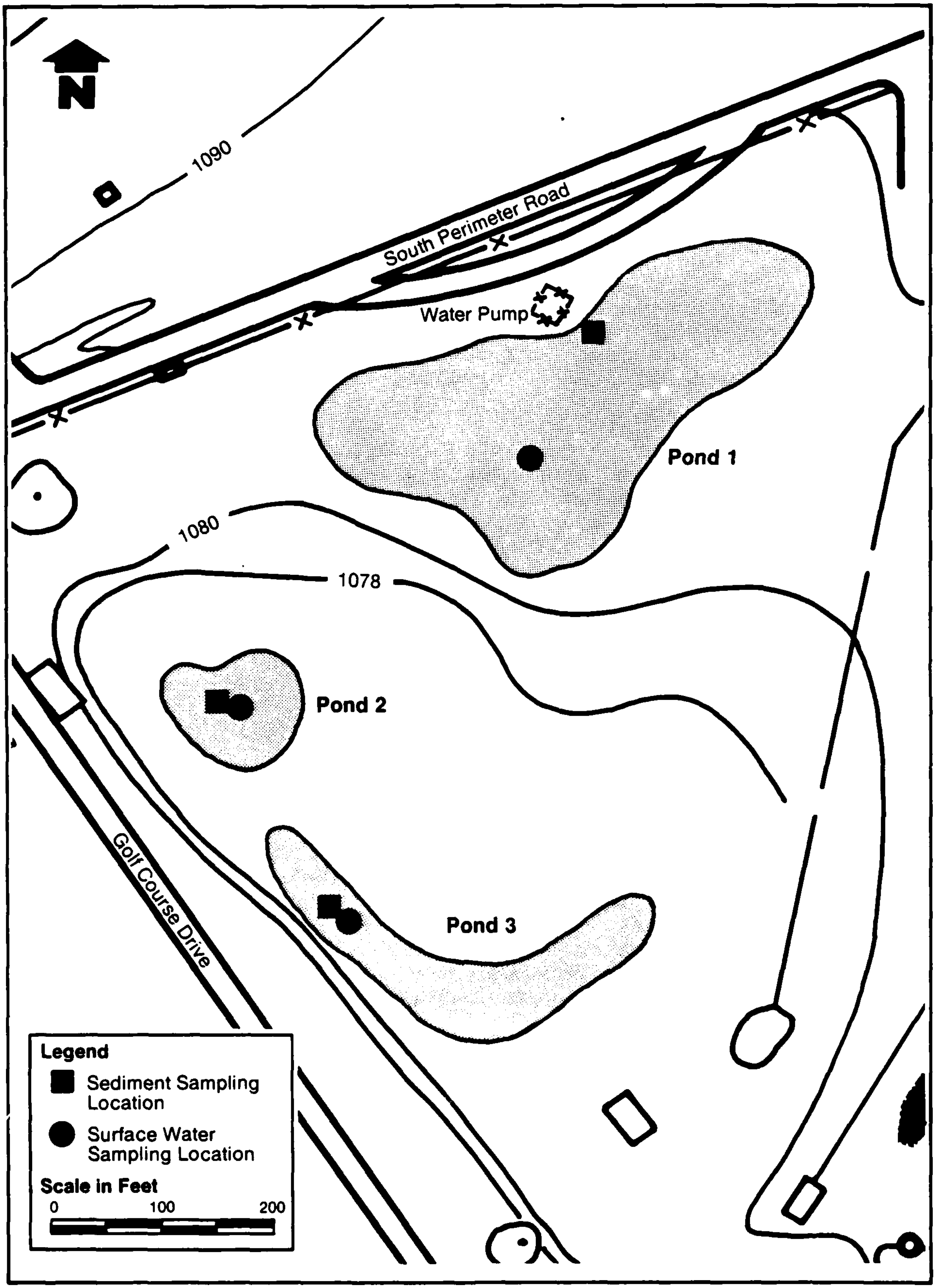

FIGURE 3-15 POND SAMPLING LOCATIONS

In Pond 1, the seine net picked up only smaller fish from the shore area, and could not be used to gather a representative population. Neither electroshocking nor fishing with a line and hook were successful for collecting larger fish from the bottom.

A first round of fish samples were collected from the three ponds on 8 July 1984, and included a few larger fish from Pond 1, as well as representative samples from Ponds 2 and 3. These samples were destroyed during shipment. A second round of fish samples was collected on 30-31 July 1984. At this time, only smaller individuals could be obtained from Pond 1, although the seine net was successful for collecting representative samples again in Ponds 2 and 3. Species collected in Pond 1 included bluegill, 4 years or older and 205 to 245 mm in length, and smallmouth bass, one year or older and approximately 125 mm in length. Collected fish were wrapped in plastic wrap, frozen, and shipped overnight mail to the WESTON laboratory for analysis.

In the laboratory, samples were sorted by species and prepared for analysis. Due to the rarity of species, feeding habits, sizes and ages encountered, a total of 5 separate samples were composited for analysis from available fish samples. A summary of the compositing procedure is presented in Table 3-8. All fish were filleted except for young-of-the-year bluegill, which were blended into a slurry of total body tissue and filtered. Hybrid sunfish were combined into single sunfish samples.

Laboratory procedures used to ash and analyze the tissue samples are reproduced in Appendix I. They were obtained from Pennsylvania DER (1977). Chromium and arsenic were analyzed by Furnau Atomic Absorption (AA); lead, cadmium, nickel, copper and zinc by ICP (USEPA Method 200.1).

SECTION 4

RESULTS

4.1. RESULTS OF THE GPR SURVEY

The product of the GPR Survey was a series of real-time radar profiles. Interpretive maps of subsurface conditions were prepared from the profile analysis. Subsurface anomalies encountered are categorized as subsoil disturbances, high priority or low priority targets, or buried utilities. The results of this GPR Survey are reported in the following subsections.

High priority targets were extremely good signal reflectors, exhibiting a dense, parabolic signature. This type of signature is characteristic of rounded objects such as pipes, boulders, and drums. In contrast, the signatures produced by the low priority targets were characteristically less dense and more variable in geometric configuration. Occasionally this signature difference is a result of the orientation of the buried object with respect to the antenna traverse, (i.e. a buried drum in a vertical plane with the ground surface typically exhibits a hyperbolic signature.)

4.1.1. GPR Findings at Site No. 1 (Industrial Waste Lagoon) and Site No. 4, (Waste Pit No. 1)

Figure 4-1 is the interpretive map of subsurface conditions at Sites 1 and 4, based on the GPR Survey. Subsurface disturbances suspected of being underneath Site No. 1 could not be detected by Ground Penetrating Radar. The old lagoons were probably completely destroyed during regrading for Golf Course construction. No other significant findings could be made at this site.

At Site No. 4, a subsurface disturbance was encountered modifying the survey area parallel to traverse 10 (T-10). Based on the GPR profile interface, the configuration of the disturbance boundary, and examination of old aerial photographs, it is suspected that this anomaly is a reflection of an old road bed that crossed the site before it was incorporated into the Golf Course. Another disturbance was detected along traverse 8 (T-8) between traverses 3 and 5 (T-3 and T-5). One high priority target was found in traverse 3 (T-3) east of traverse 12 (T-12). A smaller, low priority target was found on traverse 5 (T-5).

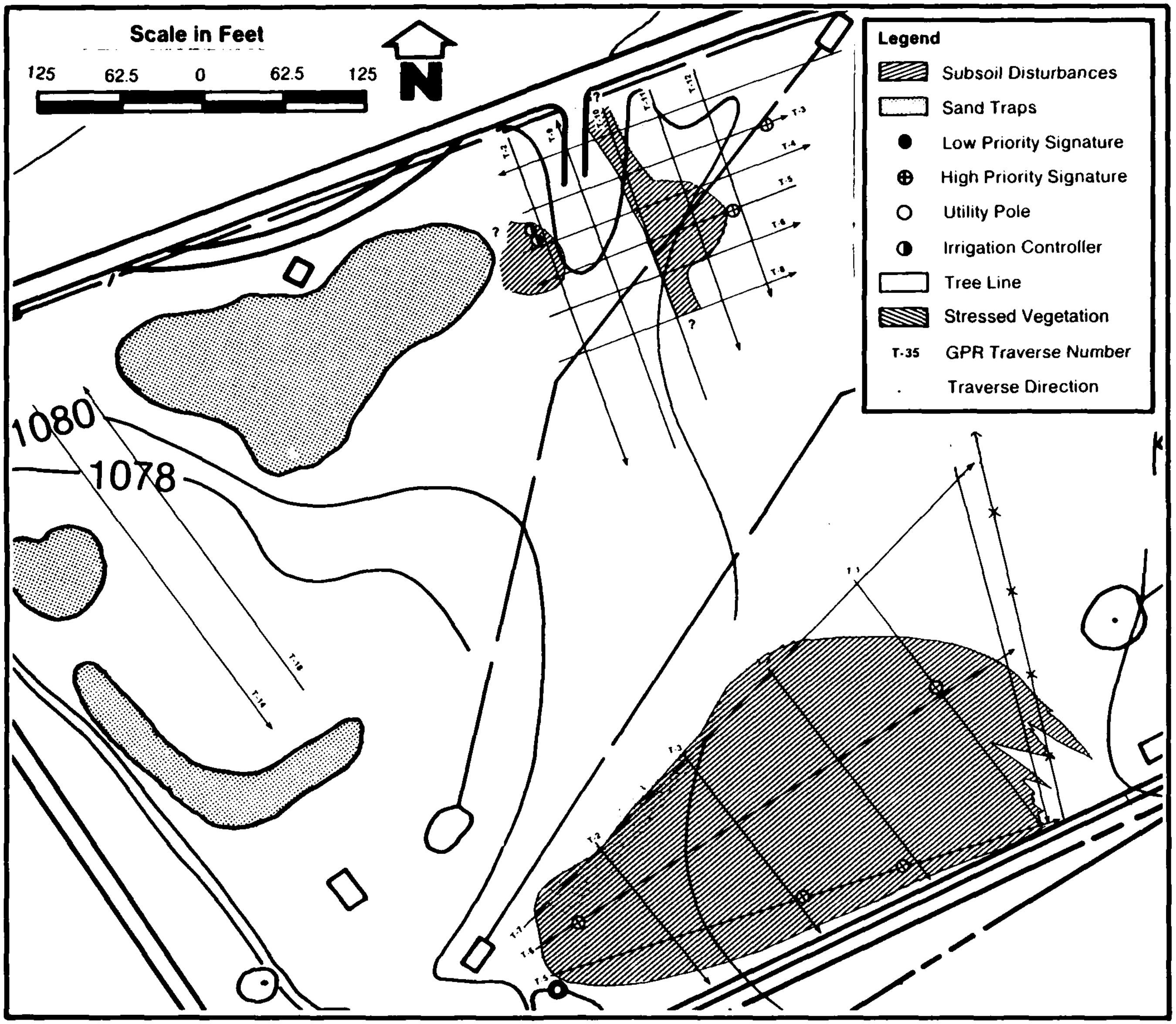

FIGURE 4-1 ZONE 1, SITES 1, 4 AND 10, INTERPRETATIVE MAP OF SUBSURFACE CONDITIONS BASED ON GPR SURVEY

The configuration of the high priority target is similar to that contained in the past from buried drums.

4.1.2 GPR Findings at Site No. 3 (Waste Pit No. 2)

Site No. 3 is located in the southern portion of the Golf Course Clubhouse parking lot. Subsurface conditions at Site No. 3 are depicted in the interpretive map of subsurface conditions in Figure 4-2, based on the GPR Survey. A subsurface disturbance was detected by the GPR underlying a major portion of the survey area. High density profiles indicate the presence of highly conductive subsoils. This condition is reflected by the elevated specific conductance values (1480 umhos/cm) of the groundwater sampled at Well MW-3. Well-defined trench-like boundaries were encountered in the northern and southern portions of the survey area, and extend east and west beyond the fenced parking lot area. This site exhibited the greatest depth of disturbance (approximately 16 to 20 feet) among all the sites surveyed. Three high priority targets, two at traverse 9 (T-9) and one between traverses 5 and 6 (T-5 and T-6) were detected. One low priority target was detected at traverse 6 (T-6). An east to west surficial depression in the asphalt may be indicative of differential settlement of loosely compacted subsoils. Based on the above factors and information available from the Phase I investigation, it is suspected that the material underlying the survey area is a mixture of unconsolidated fill and metal deposits.

4.1.3 GPR Findings at Site No. 10 (Landfill 1)

The interpretive maps of the subsurface of Site 10 are depicted in Figures 4-1 and 4-3. Figure 4-1 shows the western portion of the site, and Figure 4-3 represents the central and eastern portions of the site. Two major alterations in the subsoils were encountered in the extreme western and eastern portion of the survey area (Figures 4-1 and 4-3, respectively). Numerous high priority drum-like targets were detected and are plotted on the maps. However, because the GPR detects differences in geometric configuration and conductivities, and sees buried drums and boulders in the same likeness, it is impossible to differentiate between them. Based on the geology of the Santa Ana River Basin and site drilling logs, it is believed that the deeper materials within the two areas are lateral components of the Santa Ana River channel deposits. It is

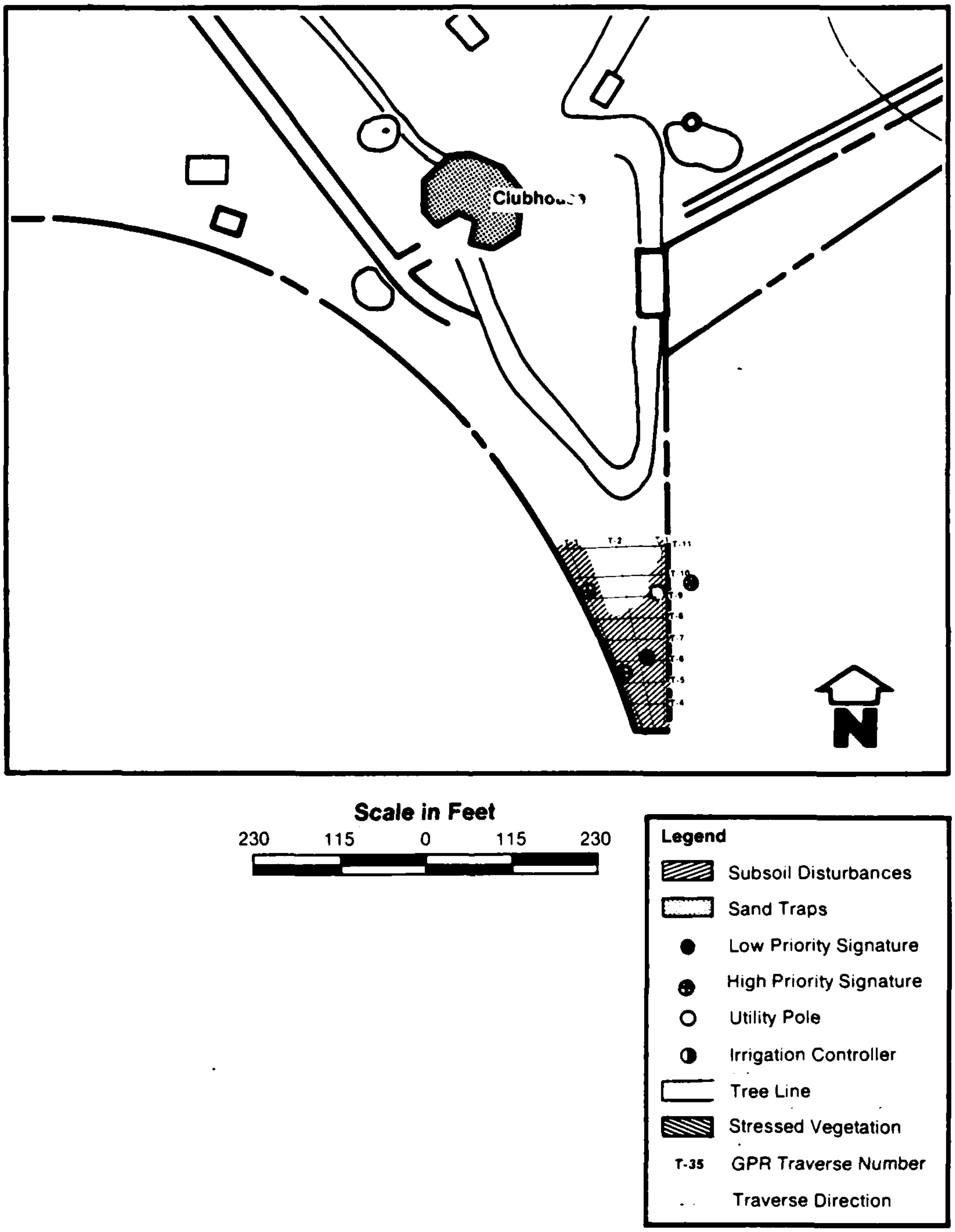

FIGURE 4-2 ZONE 1, SITE 3 INTERPRETATIVE MAP OF SUBSURFACE CONDITIONS BASED ON GPR SURVEY

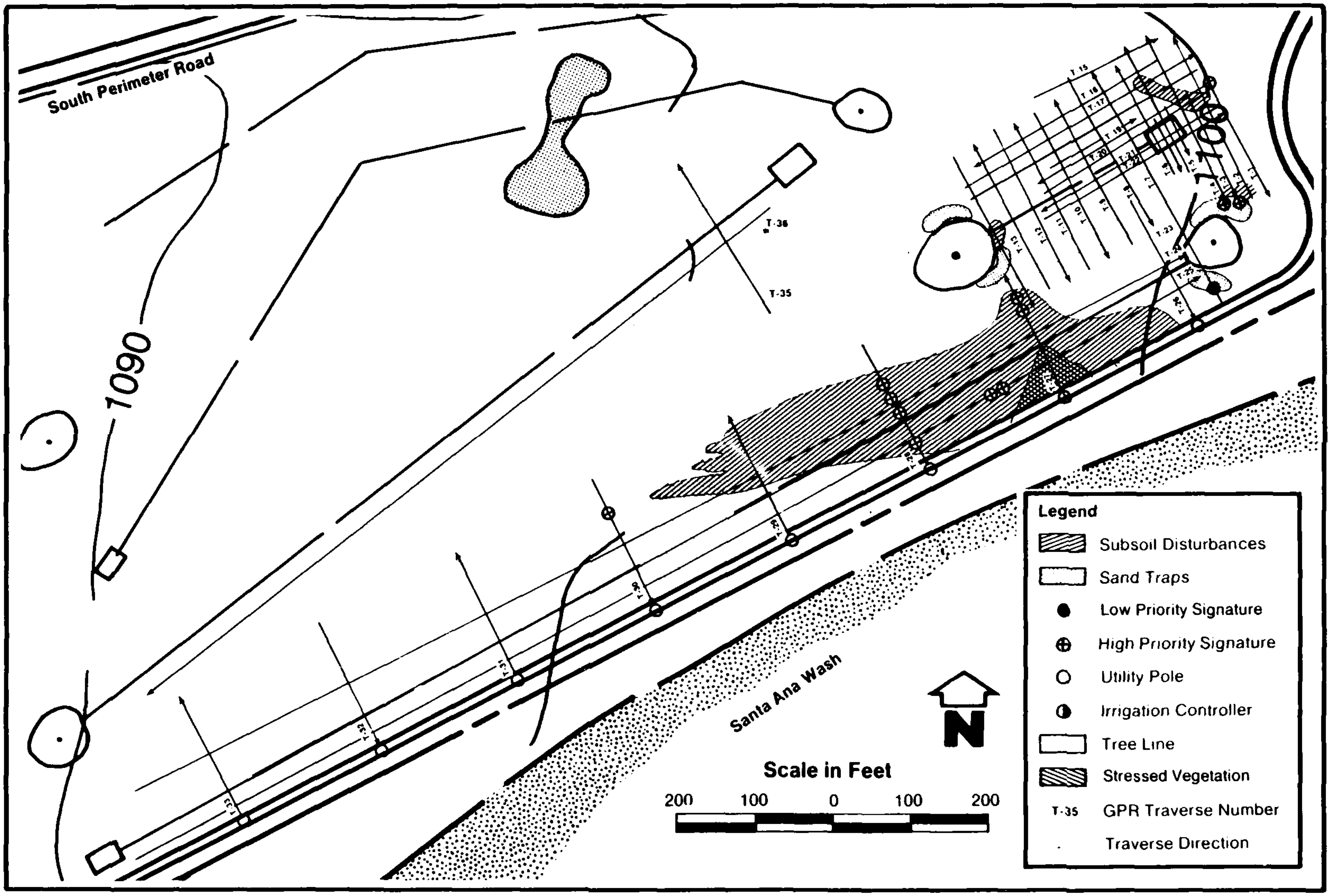

FIGURE 4-3 ZONE 1, SITES 10 AND 12, INTERPRETATIVE MAP OF SUBSURFACE CONDITIONS BASED ON GPR SURVEY

also suspected that a majority of the high priority targets detected are boulders of the Younger Alluvial deposits.

4.1.4 GPR Findings at Site 12 (Waste Pit No. 3)

Figure 4-3 is an interpretive map which characterizes the subsurface conditions at Site 12, based on the GPR data analysis. This figure depicts the various subsurface anomalies encountered by the GPR. Individual signatures (targets) are prioritized as either high or low, depending upon the density and geometric configuration of the signature profile. Three minor subsoil disturbances were detected in the survey area, as seen in Figure 4-3. Two small disturbances were located east of Golf Green 16 and also north of Golf Green 15. These areas are suspected of being local disturbances, possibly associated either with the construction of the greens, including saturated subsoils of higher permeability adjacent to sand traps, or remnants of old disposal areas. Two high priority targets were detected within the area north of Golf Green 15. A larger subsoil disturbance was encountered north of Golf Tee 16. This area measured approximately 25 feet north to south by 110 feet east to west by 8 to 12 feet deep. A high priority target was detected near the eastern boundary. Based upon the GPR profile characteristics, this area may be a remnant of the decomposed organics reported to have been buried in Waste Pit No. 3. The subsoil surrounding the three disturbed areas appear relatively homogenous having little areal variation and no detectable signatures.

4.2 SITE INTERPRETIVE GEOLOGY

Monitoring wells installed by WESTON for the Phase II Confirmation Stage (Stage 1) investigation were designed to penetrate approximately twenty feet into the uppermost water-bearing zone beneath each site. The twenty-two wells were drilled in localized areas of the Base, primarily in the northeast sector (Zones 2 and 6), along the south central perimeter (Zones 1 and 4), and in the main industrial part of the Base in the northwest sector (Zones 3 and 5). Total drilled depths ranged from 30 to 90 feet, averaging 60 feet. Based on a review of geological information available in the Phase I report for Norton AFB (ESI, 1982), these wells were expected to penetrate Younger Alluvium of Quaternary age, and Recent River Channel Deposits where they overlie the alluvium. These are both unconsolidated formations composed predominantly of sand,

with a high fraction of gravel, cobbles and boulders throughout the River Channel Deposits and occurring in buried channels in the Younger Alluvium. The upper Younger Alluvium grades westward from a predominantly sandy to predominantly silty composition.

In general, subsurface conditions encountered during the drilling program conformed to these predicted conditions. In the northeast sector, around the Landfill Waste Management Zone (Zone 2) and the AAVS/DAVA Evaporation basins (Zone 6), sediments penetrated in the top 60 feet consisted of alternating beds of sand, gravelly sand, and gravel and cobbles. In the northwest sector (Zones 3 and 5), the predominant fraction was sand down to approximately 60 feet, with a gravel and cobble zone at 15-25 feet below ground surface, and a layer of sandy silt approximately 5 feet thick at 30 to 35 feet below ground surface. Along the southern boundary, in the Golf Course Waste Management Zone (Zone 1) and the IWTP Waste Management Zone (Zone 4), sand, gravelly sand, and gravel and cobbles were encountered down to depths of 20 to 40 feet. In Zone 1 these coarser sediments were underlain by alternating sequences of sand, silty sand and sandy silt down to a depth of 45 to 50 feet, followed by sand to a depth of at least 60 feet.

It is concluded that the upper 60 feet of alluvium underlying the Base consists primarily of sand, with a high portion of gravel and cobbles in the top 10 to 20 feet, particularly near the Santa Ana Wash. Whereas little to no silt is encountered in the alluvium beneath the eastern sector of the Base, both the frequency of occurrence and the thickness of silty sand and sandy silt layers increase toward the west and southwest.

A more detailed description of subsurface lithology as it impacts groundwater conditions is provided in the following section on a zone-by-zone basis.

4.3 SITE GROUNDWATER CONDITIONS

4.3.1 General

Groundwater conditions in the shallow subsurface beneath the Base are affected both by the lithology as described in the previous section and by the regional setting within the Bunker Hill Basin.

Groundwater occurs under water-table conditions (i.e. in equilibrium with atmospheric pressure) in the northeast sector (Zones 2 and 6), at a depth of 40 to 45 feet below ground surface. Moving west-southwest beneath the area of Norton AFB, lenses of silty sand, sandy silt and silt occur with increasing frequency. Where these lenses merge to form a continuous aquitard, or confining layer, above the principal water-bearing zone, or aquifer, groundwater in this aquifer occurs under confined conditions. A separate, shallow water-table aquifer occurs above the confining layer. This condition exists along the southern boundary of the Base in Zone 1 (the Golf Course Waste Management Zone). Wells screened in the two separate aquifers exhibit differences in water level reflecting the difference in water pressure between the shallow groundwater aquifer and the principal aquifer, and document the existence of a downward-directed vertical hydraulic gradient between the two water bearing zones.

Groundwater levels measured on July 5 and 6, 1984 (reported in Table 3-5) were used to develop a generalized groundwater level map, shown in Figure 4-4, for the area of Norton AFB as a whole. Well logs were carefully reviewed, and on the western half of the Base only water levels from those wells which were screened just below the silt zone were used for the groundwater map, so that a picture of horizontal flow in the principal, or regional aquifer, would be obtained. Water levels measured in wells screened above the silt zone (MW-1, MW-3, MW-10, MW-20, MW-21, MW-22), or in a lower portion of the principal aquifer (MW-2) were not used in preparing the map.

The resulting map (Figure 4-4) indicates that groundwater in the principal aquifer beneath the Base flows downgradient (perpendicular to the contour lines) approximately parallel to the Santa Ana River, in a west-southwesterly direction. Due to the clustered distribution of monitoring wells across the Base, only a very generalized picture could be obtained, and local anomalies related to the effect of pumping wells or other conditions could not be accounted for in the ground water level map. The hydraulic gradient along the southern perimeter appears very uniform, equalling approximately 0.008 beneath both the western end of the Base and the Golf Course, and sloping to the west-southwest. This is approximately parallel to the regional gradient in deeper aquifers as illustrated in Figure 2-5.

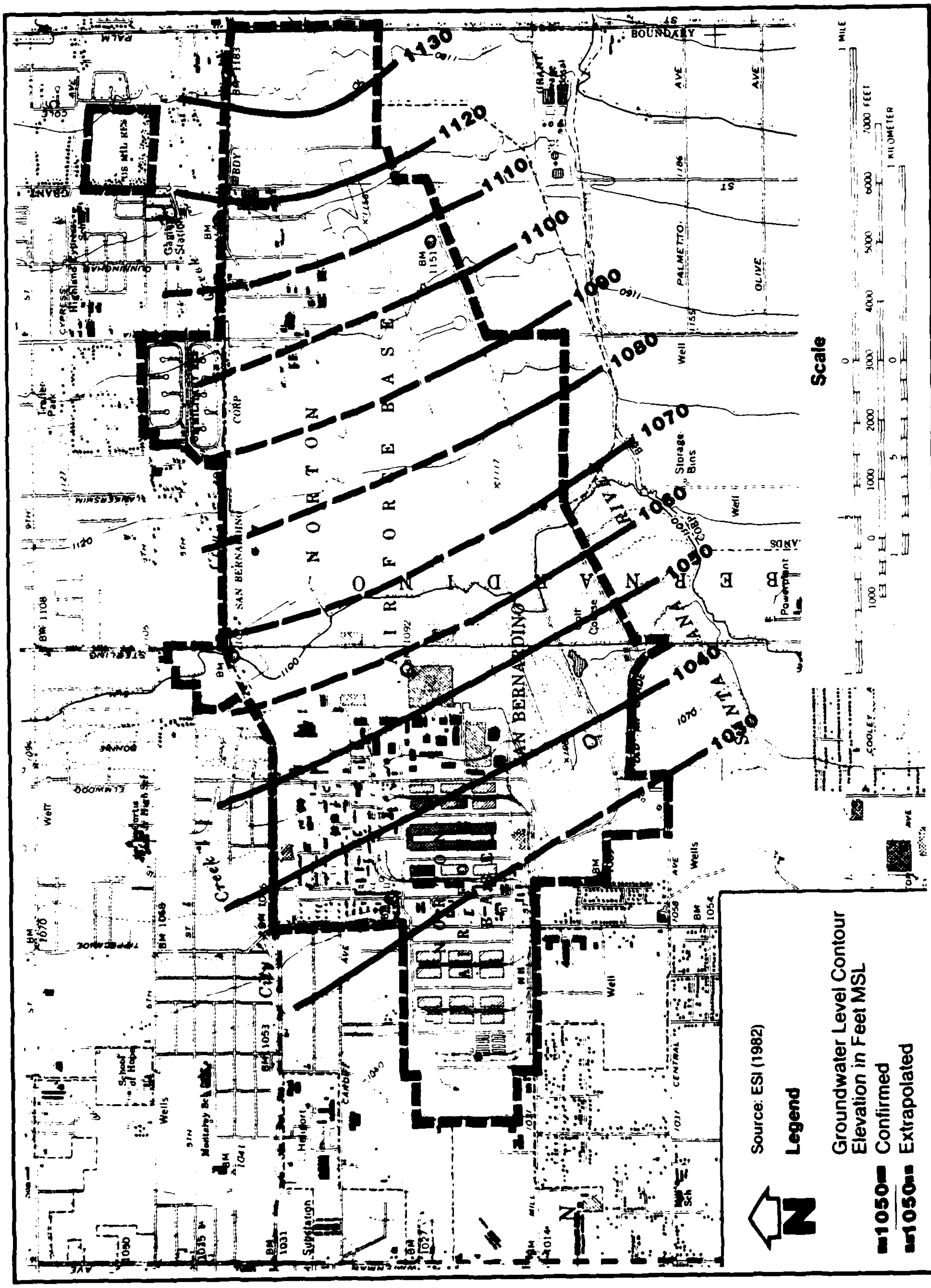

FIGURE 4-4 GENERALIZED GROUND WATER LEVEL MAP OF NORTON AFB

A rough estimate of lateral flow velocities in the principal aquifer can be obtained by using an average hydraulic gradient of 0.008 and making some assumptions concerning aquifer properties on the basis of observed lithology and available literature. Dutcher and Garrett (1963) cited a value of hydraulic conductivity for the Younger Alluvium in the Santa Ana floodplain downstream from the San Jacinto Fault equal to 360 feet/day. This is within the range of values available in the literature for the horizontal hydraulic conductivity of sandy alluvium, i.e. between 150 to 3000 feet/day (Todd, 1980; Davis and DeWiest, 1963). Porosity varies over a narrow range in sandy sediment, and can be estimated at 0.30. The equation for horizontal flow velocity can be written:

$$v = Ki/n$$

where K = horizontal hydraulic conductivity, in feet/day

i = hydraulic gradient, dimensionless

n = effective porosity, dimensionless.

Substituting 360 feet/day for hydraulic conductivity, 0.008 for hydraulic gradient, and 0.30 for porosity, the estimated flow velocity in the principal aquifer is 10 feet/day.

4.3.2 Zone-Specific Conditions

The groundwater conditions discussed in a general manner above are reviewed on a Zone-by-Zone basis to better develop the relationships between lithology, ground water occurrence and groundwater flow direction, as well as the implications for contaminant migration in the immediate vicinity or each zone. In some cases where nearby wells can help to clarify groundwater conditions, adjacent zones are discussed together.

4.3.2.1 Groundwater Conditions in Zone 1, the Golf Course Waste Management Zone

Selected wells in Zone 1 have been used to prepare a geologic cross-section along a line running approximately parallel to the Santa Ana Wash along the southern Base boundary, as shown in Figure 4-5. The cross-section, shown

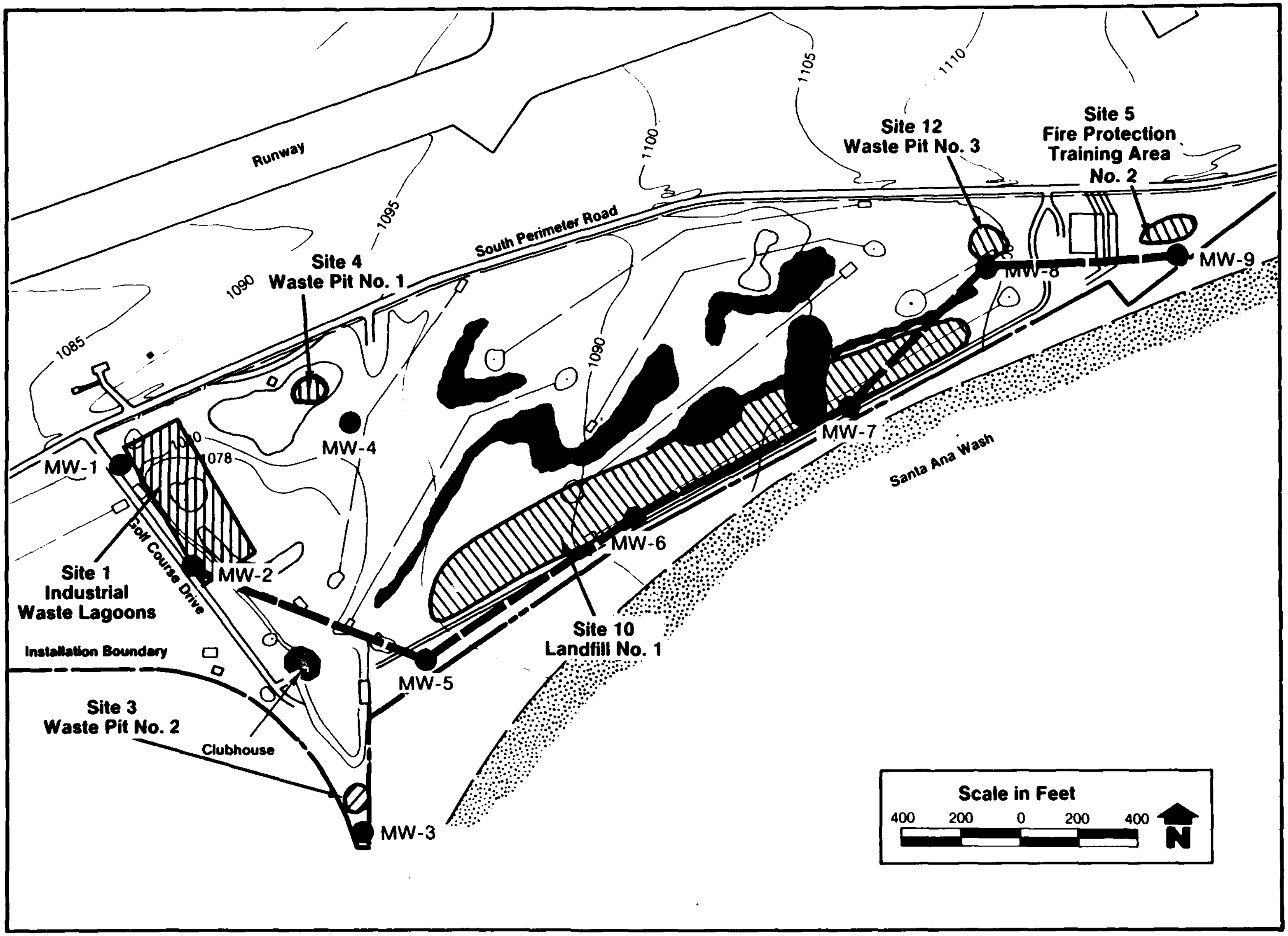

FIGURE 4-5 INDEX MAP FOR ZONE 1 SHOWING LINE OF GEOLOGIC CROSS-SECTION

in Figure 4-6, indicates clearly that the upper 60 feet of alluvium can be divided into three hydrogeologic strata: an upper sand and gravel layer with localized buried cobble zones from 20 to 40 feet thick; a middle silt and sandy silt zone composed of lenses of silt, sandy silt and silty sand, forming a more-or-less continuous confining layer from 5 to 12 feet thick; and a lower sand layer extending from a depth of 35 to 45 feet below ground surface to at least 60 feet. MW-2, the only well drilled below a depth of 60 feet, penetrated a lower silty sand and sandy silt layer at depths between 58 and 72 feet, and is screened in sand below that layer.

The fact that the middle (silt) layer acts as a confining layer is demonstrated by the water levels measured on July 5-6, 1984, reported in Table 3-5 and displayed in Figure 4-7. The two wells screened in the upper sand and gravel layer, MW-1 (total depth 46 feet) and MW-3 (total depth 31 feet), had measured water level elevations 15 to 20 feet higher than adjacent wells screened in the lower sand layer. For this reason, two groundwater aquifers are distinguished in this Zone: the shallow water-table aquifer in the sand and gravelly sand above the confining silt layer (monitored by MW-1 and MW-3), and the "principal" or regional aquifer (monitored by wells MW-4 through MW-9) in the sand below the silt layer. The water level contours shown in Figure 4-7 have been drawn based on water level elevations measured in MW-4 through MW-9, and are therefore representative of the principal aquifer. They indicate that groundwater flow in this aquifer is to the southwest, along a uniform hydraulic gradient of approximately 0.008. It should be noted that the regional aquifer in this area is probably quite complex. The main sand body is broken into several piezometric levels by fingers of silt and clay which merge and thicken to the southwest. This is demonstrated by the water level in MW-2, which is 1 to 2 feet lower than would be expected based on the gradient observed in MW-4 through MW-9, probably because it is screened in a lower sand zone. Therefore, MW-4 through MW-9 monitor only the upper level in the regional semi-confined aquifer, which in this area appears to have a downward vertical gradient as well as a horizontal gradient to the southwest.

The direction of flow in the water table aquifer cannot be accurately determined on the basis of two wells. However, based on the two water levels measured in MW-1 and MW-3 the groundwater gradient would appear to be to the north or

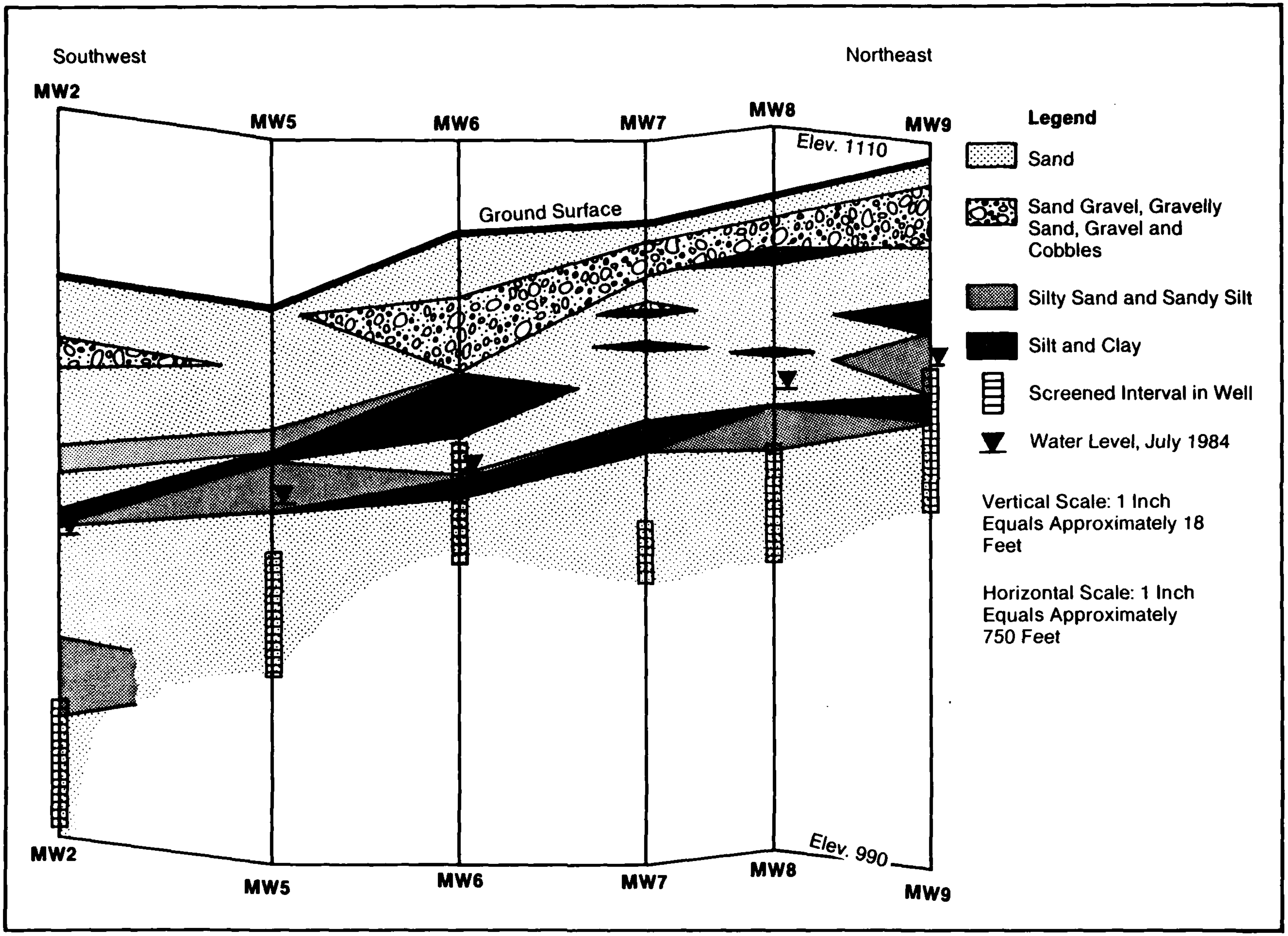

FIGURE 4-6 ZONE 1, GEOLOGIC CROSS-SECTION ALONG SOUTHERN BOUNDARY

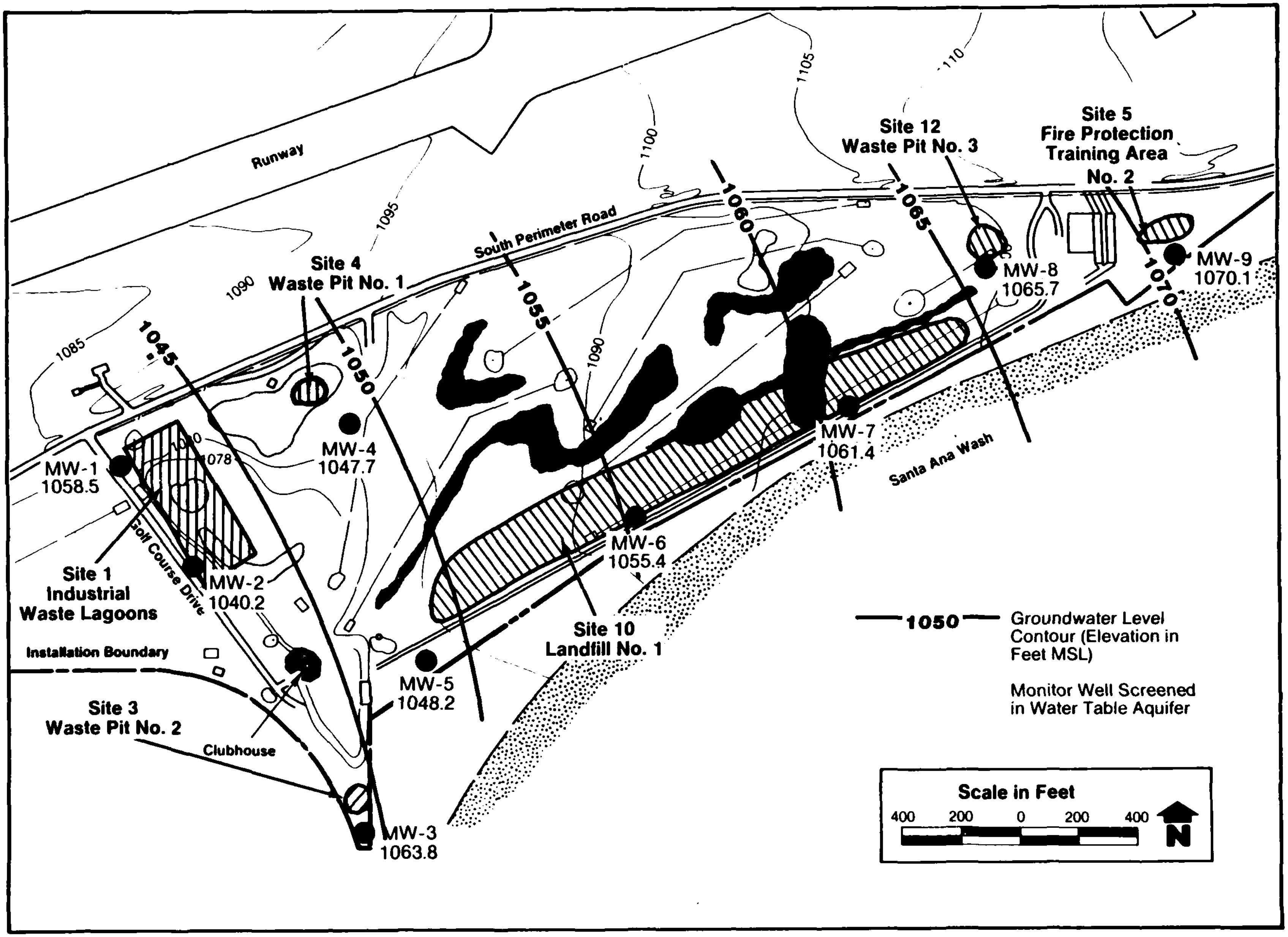

FIGURE 4-7 ZONE 1, GROUND WATER LEVEL MAP FOR PRINCIPAL AQUIFER

northwest, away from the Santa Ana Wash. Based on the USGS Topographic Quadrangle map, the bottom of the Wash immediately south of MW-3 has an elevation of approximately 1075 feet MSL, or 10 feet higher than the water level measured in MW-3 in July 1984. If there is ground water flow in the shallow water-table aquifer away from the Santa Ana Wash, it may be intermittent and dependent on storm events, or seasonally related. The direction of flow in this Zone may vary considerably over the course of a year. A more extensive network of wells and long-term water level monitoring would be required to more accurately evaluate flow in this Zone.

One other factor potentially affecting groundwater levels in Zone 1 is the golf course irrigation program. Due to the application of large amounts of irrigation water and the significant infiltration rates in this area, it is possible that water levels in this Zone are being maintained artificially high relative to other sections of the Base. This is a factor which would also affect water levels in Zone 4, the IWTP Waste Management Zone, which is bordered on two sides by irrigated golf course property.

Based on these findings, there is a high likelihood that any contamination which may have been generated in the past or is still occurring in the vicinity of the sites identified in the Golf Course Waste Management Zone would have reached the shallow groundwater aquifer beneath this zone. Soils immediately underlying the Zone are sandy and therefore highly permeable, and the application of irrigation water would have resulted in increased percolation rates relative to natural percolation since 1961. However, the direction of ground water flow in the shallow water-table aquifer and the degree of hydraulic connection and solute migration between this aquifer and the regional aquifer cannot be accurately determined without further field investigation.

4.3.2.2 Groundwater Conditions in Zone 2, the Landfill Waste Management Zone, and Zone 6, the AAVS/DAVA Evaporation Basins

Based on well logs for MW-11 through MW-13 and MW-16 through MW-19, subsurface sediments beneath the northeast sector (which includes Zones 2 and 6) are composed of alternating layers of sand, gravelly sand, and coarse gravel and cobbles. Only minor amounts of silty sand and silt

seams were reported in a few of the well borings. Groundwater in this area occurs under water-table conditions at a depth of 40 to 45 feet below ground surface. Figure 4-8 is a groundwater level map based on values reported in Table 3-5. Based on this map, the water-table roughly parallels surface topography, sloping to the west at a gradient of approximately 0.008.

Both Landfill No. 2 and the Fuel Sludge Disposal Area began operation as disposal areas in 1958. The Fuel Sludge Disposal Area was closed in the mid 1970's, Landfill No. 2 in 1980. The AAVS/DAVA Evaporation Basins have been operated intermittently since 1968. Trenches in Landfill No. 2 were reportedly excavated down to 20-40 feet below ground-surface, and the pit at the southwest corner used for lithium battery disposal was 40 to 50 feet deep (ESI, 1982). Clearly, the fill in many areas of Landfill No. 2 is within 10 feet of the current water-table, whereas the surface sites (the Fuel Sludge Disposal Area and the AAVS/DAVA Evaporation Basins) are 40 to 45 feet above the water table. Based on lithologies encountered in the well borings, there exist no significant barriers to vertical flow beneath this area.

4.3.2.3 Groundwater Conditions in Zone 3, the Underground Waste Oil Storage Tank and Zone 5, Waste Pit No. 4

Both Zone 3 and Zone 5 are located in the northwest sector, or industrial area, of the Base. A single monitor well was drilled in each Zone, adjacent to and in the presumed downgradient direction from each study site: MW-14 in Zone 5 (Site 14), Waste Pit No. 4, in the Civil Engineering Yard; and MW-15 in Zone 3 (Site 6), the Underground Waste Oil Storage Tank, within the area of the newly expanded Base Service Station.

Sediments penetrated by the two wells were lithologically similar, consisting principally of sand and gravelly sand, with a distinct gravel and cobble zone from 2 to 5 feet thick encountered at depths of 14 to 25 feet, and a sandy silt zone from 3 to 7 feet thick at depths of 30 to 35 feet. Based on the well logs, the degree of saturation of sediments, and later water level measurements, groundwater occurs under unconfined conditions in MW-15 but under confined conditions in MW-14, with an overlying water-table

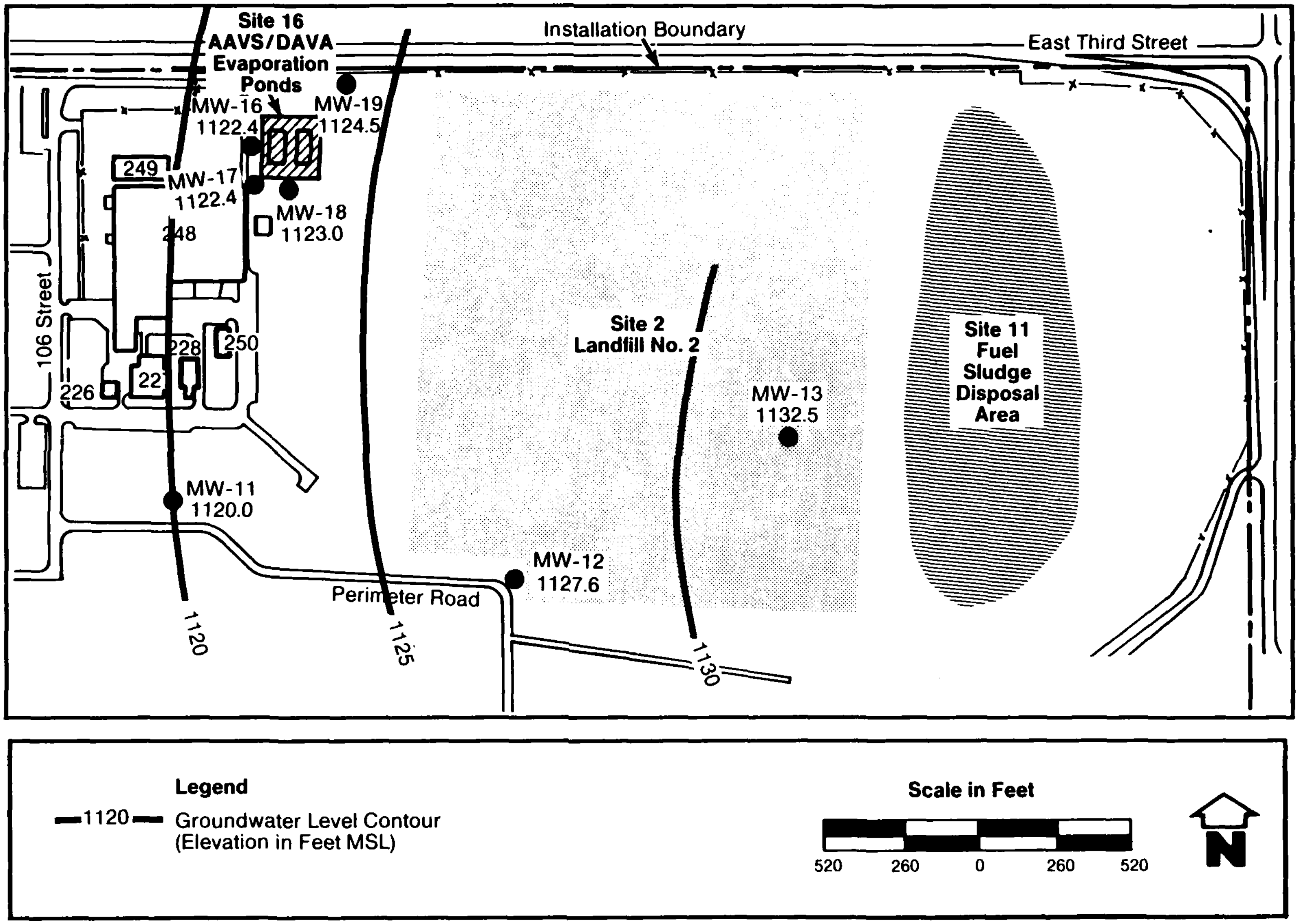

FIGURE 4-8 ZONES 2 AND 6, GROUND WATER LEVEL MAP

aquifer approximately 5 feet thick in the sand above the silt zone at that location.

MW-15 was installed at a location approximately 2600 feet east of and 20 feet higher than MW-14, and its water level elevation is 13.6 feet higher. This represents a hydraulic gradient in the principal aquifer of approximately 0.005, although the true slope and direction of the gradient cannot be estimated on the basis of only two measuring points.

Contamination moving downward in either Zone would be expected to be retarded to some degree by the presence of a silt layer. For Zone 3 (the Underground Waste Oil Storage Tank), this layer represents a barrier to downward percolation in the unsaturated zone. In Zone 5 (Waste Pit No. 4), this represents a confining layer with a perched water-table aquifer above it. Upon reaching this shallow aquifer, contamination would move laterally as well as downward into the principal aquifer.

4.3.2.4 Groundwater Conditions in Zone 4, the IWTP Waste Management Zone

The four wells drilled in Zone 4, the IWTP Waste Management Zone, are located relatively close to each other and are only 30 to 39 feet deep. All wells were finished at an approximate elevation of 1030 feet MSL, and had a measured water level near 1045 feet MSL. MW-10 is located in the southeast corner of the IWTP compound, MW-20 and MW-21 just outside the western fence, and MW-22 in the northeast corner.

The predominant sediment type encountered in all four borings was sand, with little or no gravel. A sandy silt and silty sand layer was encountered in one hole (MW-10) between depths of 9 and 17 feet, and near the bottom of the hole in MW-10 and MW-22. From comparison with well logs and water levels in Zone 1, all four wells are finished in a shallow water-table aquifer overlying and separated from the principal aquifer by a silt layer. Except for MW-20, on the southwestern corner of the compound, the water levels in the wells are very close together (Figure 4-9), and appear to indicate slight hydraulic gradient to the northwest, away from the Santa Ana Wash. This would be consistent with the apparent gradient between MW-1 and MW-3 in Zone 1. MW-20 is located at the bottom of a well-irrigated grassy slope, in a swale. The anomalously high water level measured in MW-20

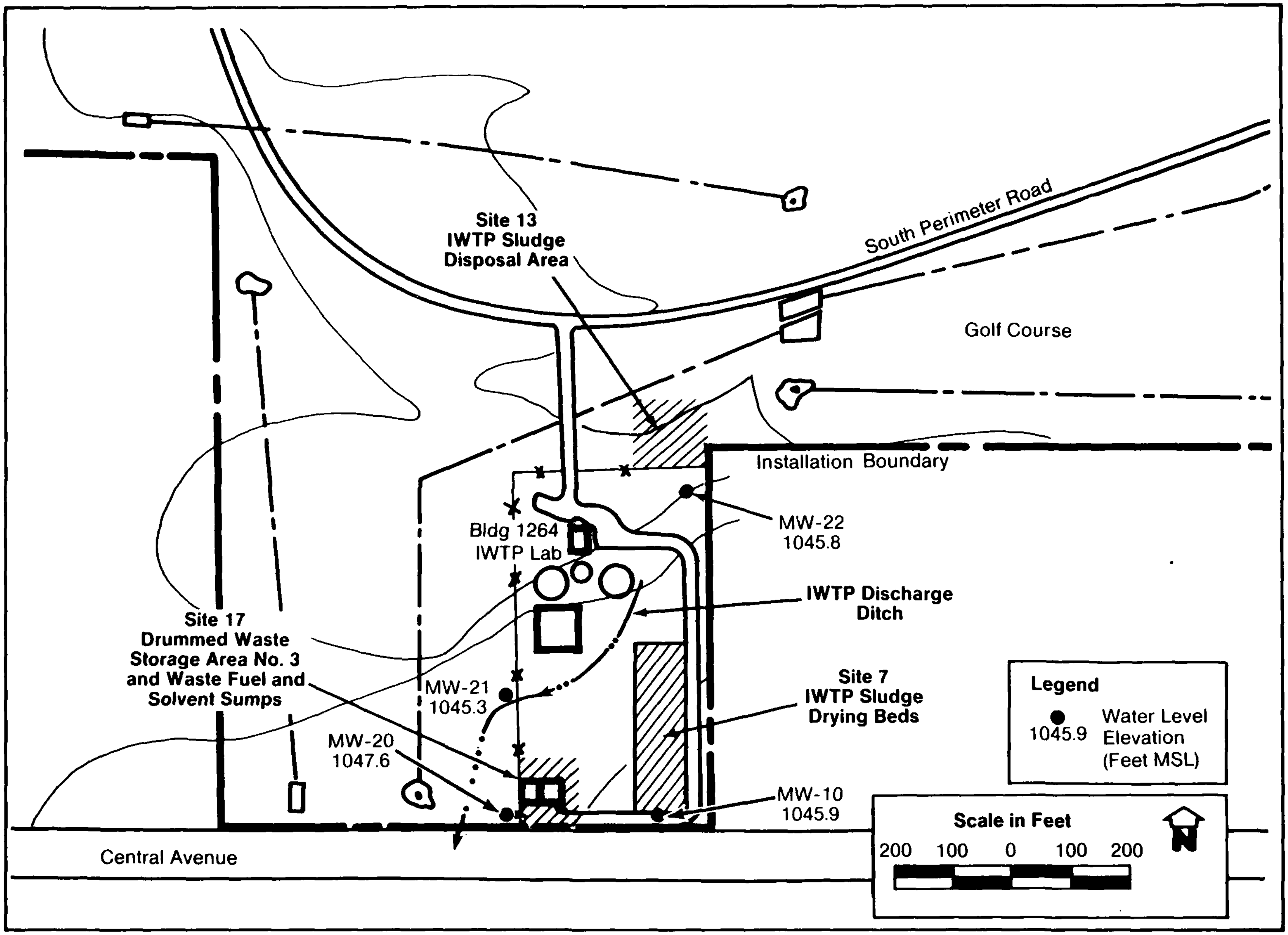

FIGURE 4-9 ZONE 4, GROUND WATER LEVEL ELEVATIONS

may be a function of ponding and infiltration of Golf Course irrigation water in the swale within which the well was completed.

Due to the absence of barriers to vertical flow and the relatively shallow depth of groundwater in this Zone (from 12 to 23 feet below ground surface), the likelihood of contamination reaching the shallow water-table aquifer from the surface by percolation is high. The direction of groundwater flow and contaminant transport in this shallow aquifer cannot be accurately determined at this time due to the relatively close well spacings and the very small differences in most measured water levels. In addition, no water level or water quality information is available for the principal aquifer beneath this site, due to the absence of monitor wells completed in that aquifer. Flow directions in the principal aquifer are most likely to be directly affected by the pumping from the nearby Gage Canal Company wells.

4.4 RESULTS OF CHEMICAL FIELD TESTS AND LABORATORY ANALYSES

This section reviews chemical data, including the results of both field measurements and laboratory analyses, obtained from environmental samples collected at Norton Air Force Base between November 1983 and July 1984. These environmental samples included groundwater, surface water, pond sediment and fish tissue. Methods used in sample collection and preparation and field testing were described in Section 3.2. Additional detail on field sampling and laboratory analytical methods is provided in Appendices F and I. The laboratory analytical reports are reproduced in Appendix K.

4.4.1 Soils Results

A total of 12 soil borings were drilled; six at Site No. 5, Fire Protection Training Area No. 2 in Zone 1, and six at Site No. 17, Drummed Waste Storage Area No. 3 and the Waste Fuel and Solvent Sumps in Zone 4. This section reviews the results of field measurements and laboratory analyses performed on soil samples collected from these borings.

4.4.1.1 Zone 1, Site No. 5, Fire Protection Training Area No. 2

Six soil borings were drilled in Fire Training Protection Area No. 2 on the perimeter of the burn area, in locations shown in Figure 3-3. The borings were drilled to a total depth of six feet and sampled continuously with a

split-spoon sampler. In some cases the hole had to be offset to reach full depth due to interference from cobbles at shallow depths. Only three samples were collected in B-1 and B-2. In the remaining boreholes 4 samples were collected from each hole for better coverage because the actual sampling interval of the split-spoon sampler was approximately 1.5 feet. In total, 22 soil samples were collected at this site.

During drilling, both the MSA Explosimeter and the HNu were used to monitor borehole atmosphere. The readings have been reported in the boring logs in Appendix D. Explosimeter readings above background were registered in two boreholes only: B-5, where the atmosphere reached 18 to 20% LEL and the oxygen level was 18 to 21%, and B-6, where the atmosphere reached 10 to 50% LEL and the oxygen level was 15 to 20%. The HNu was also used to screen split-spoon samples for contamination as described in Section 3.2.3.2. The range of HNu readings in borehole atmosphere and the individual sample readings are reported in Table 4-1. They indicate an elevated level of organic contamination in soil gas around the site at all depths, with an apparent increase between the 0 to 2 foot and the 2 to 6 foot intervals. These instruments are used only as field diagnostic tools--their responses vary widely, depending upon the volatile compound present, and these readings may not correlate directly with soil chemistry data from actual laboratory analyses.

Between two and four samples from each hole were selected for laboratory analysis of the 32 USEPA Priority Pollutant volatile organic compounds (VOA). A total of 19 samples were analyzed and duplicate extractions and analyses were performed on seven samples. The detection limits and analytical results are summarized in Table 4-2. The full analytical report is provided in Appendix K. It should be noted that methylene chloride values below 0.010 ug/g have not been reported in Table 4-2 due to the presence of this compound in laboratory blanks analyzed during the same period. Table 4-2 indicates that soils are contaminated with several VOA compounds in all of the boreholes at this site, primarily with fuel additives (benzene, toluene and ethylbenzene) on the order of 0.1 to 100 ug/g (particularly in B-1 and B-2), and secondarily with chlorinated hydrocarbons (such as trans 1,2-dichloroethane, trichloroethylene, and tetrachloroethylene) on the order of 0.001 to 0.150 ug/g.

4.4.1.2 Zone 4, Site No. 17, Drummed Waste Storage Area No. 3 and Waste Fuel and Solvent Sumps

Six soil borings were drilled in Drummed Waste Storage Area No. 3, two each on the north, east and south side of the

TABLE 4-1

SUMMARY OF HNu MEASUREMENTS IN SOIL BORINGS,
ZONE 1, SITE 5, FIRE PROTECTION TRAINING AREA NO. 2

Borehole Number:		B-1	B-2	B-3	B-4	B-5	B-6
1. Range in Borehole Atmosphere		7-50	0-180	0-5	20-100	5-200	10-200
2. Individual Sample Readings, by depth interval (feet):							
0 -1.5				30	150	70	60
	0-2	50	60				
1.5-3.0				130	150	130	120
	2-4	130	150				
3.0-4.5				130	140	180	100
	4-6	50	60				
4.5-6.0				130	200	150	100

Note: All measurements in ppm relative to hexane

TABLE 4-2

SUMMARY OF ZONE 1, SITE 5, SOIL ANALYSES
FOR USEPA PRIORITY POLLUTANT VOA COMPOUNDS

COMPOUND	DETECTION LIMIT SEDIMENT	B-1				B-2				B-3			
		0-2'	2-4' [1]		4-6'	0-2'	2.4'	4-6' [1]		1.5-3'	3-4.5' [1]		4-5.5'
	(ug/g)												
Chloromethane	.0008	-	-	-	-	-	-	-	-	-	-	-	-
Bromomethane	.0118	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	.0101	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	.0018	-	-	-	-	-	-	-	-	-	-	-	-
Chloroethane	.0032	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	.0025	-	-	-	-	-	-	-	-	-	-	-	-
Trichlorofluoromethane	.010	-	-	-	-	-	-	-	-	-	-	-	-
1,1 Dichloroethene	.0013	-	-	-	-	-	-	-	-	-	-	-	-
1,1 Dichloroethane	.0007	-	-	-	-	-	-	-	-	-	-	-	-
Trans 1,2 Dichloroethene	.001	-	-	-	-	-	-	-	-	-	-	-	-
Chloroform	.0005	-	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichloroethane	.0003	-	-	-	-	-	-	.0025	-	-	-	-	-
1,1,1-Trichloroethane	.0003	-	-	-	-	-	-	-	-	-	-	-	-
Carbon tetrachloride	.0012	-	-	-	-	-	-	-	-	-	-	-	-
Bromodichloromethane	.001	-	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichloropropane	.0004	-	-	-	-	-	-	-	-	-	-	-	-
Trans 1,3-Dichloropropene	.0034	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	.0012	-	.0017	-	-	-	-	-	-	-	-	-	-
Dibromochloromethane	.0009	-	-	-	-	-	-	-	-	-	-	-	-
1,1,2 Trichloroethylene	.0002	-	-	-	-	-	-	-	-	-	-	-	-
Cis 1,3-Dichloropropene	.002	-	-	-	-	-	-	-	-	-	-	-	-
2-Chloroethylvinylether	.0013	-	-	-	-	-	-	-	-	-	-	-	-
Bromoform	.002	-	-	-	-	-	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	.0003	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	.0003	-	.0012	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	.0025	-	-	-	-	-	-	-	-	-	-	-	-
1,3 Dichlorobenzene	.0032	-	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichlorobenzene	.0015	-	-	-	-	.004	-	-	-	-	-	-	-
1,4 Dichlorobenzene	.0024	-	-	-	-	-	1.	-	-	-	-	-	-
Benzene	.1	-	1.1	.5	-	.41	1.2	-	.83	.41	-	-	-
Toluene	.1	-	1.3	1.3	-	-	8.	-	-	-	-	-	-
Ethylbenzene	.1	-	10.	10.	-								
Number of unidentified peaks		0	0 (3)	0 (3)	0	0 (3)	0 (3)	0 (3)	0 (3)	0 (3)	0	0	0

NOTES:

1 Compounds analyzed but not found above detection limit
2 Duplicate analyses
3 Methylene chloride values below .01 ug/g not reported
Unknown hydrocarbon mixture present in sample

TABLE 4-2 (Cont.)

SUMMARY OF ZONE 1, SITE 5, SOIL ANALYSES
FOR USEPA PRIORITY POLLUTANT VOA COMPOUNDS

COMPOUND	DETECTION LIMIT SEDIMENT (ug/g)	B-4 0-1.5	B-4 1.5-3'[1]		B-4 3-4.5'	B-4 4.5-6'[(1)]		B-5 0-1.5'[(1)]		B-5 3-4.5'	B-6 0-1.5'	B-6 1.5-3'[(1)]		B-6 3-4.5'	B-6 4.5-6'
Chloromethane	.0008	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromomethane	.0118	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	.01811	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	.00188	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroethane	.0052	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	.0025 (2)	-	.080	-	-	-	-	-	-	-	-	-	-	-	-
Trichlorofluoromethane	.010	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1 Dichloroethene	.0013	-	.011	-	-	-	-	-	-	-	-	-	-	-	-
1,1 Dichloroethane	.0007	.017	-	-	-	-	-	-	-	-	-	-	-	-	-
Trans 1,2 Dichloroethene	.001	-	.0033	.15	-	-	-	-	-	-	-	.05	-	-	-
Chloroform	.0005	-	.0017	-	-	-	-	-	-	-	-	.006	-	-	-
1,2 Dichloroethane	.0003	-	.0053	.09	-	-	-	-	-	-	-	.03	-	-	-
1,1,1-Trichloroethane	.0003	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon tetrachloride	.0012	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromodichloromethane	.001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichloropropane	.0004	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trans 1,3-Dichloropropene	.0034	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	.0012	-	-	-	-	-	-	-	-	-	-	.077	.046	-	-
Dibromochloromethane	.0009	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1,2 Trichloroethylene	.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cis 1,3-Dichloropropene	.002	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Chloroethylvinylether	.0013	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromoform	.002	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	.0003	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	.0003	-	-	.006	-	.0093	.0043	-	-	-	-	.020	.013	-	-
Chlorobenzene	.0025	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,3 Dichlorobenzene	.0032	-	-	-	-	.0039	.051	-	-	-	-	-	-	-	-
1,2 Dichlorobenzene	.0015	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,4 Dichlorobenzene	.0024	-	-	-	-	-	.023	-	-	-	-	-	-	-	-
Benzene	.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	.1	.34	-	-	.19	-	-	-	-	-	-	-	-	.63	.083
Ethylbenzene	.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of Unidentified Peaks		0 (3)	0	0	0 (3)	0	0	0	0	0	0 (3)	1	0	0 (3)	0 (3)

NOTES:

- Compounds analyzed but not found above detection limits
(1) Duplicate analyses
(2) Methylene chloride values below .010 ug/g not reported
(3) Unknown hydrocarbon mixture present in sample

easternmost waste fuel and solvent sump (Figure 3-10). The borings were drilled to a total depth of ten feet and sampled continuously with a split-spoon sampler. In some cases, the hole had to be offset to resample an interval blocked in the first location by cobbles at shallow depths. Approximately seven samples were collected from each hole at 1.5 foot intervals. The total number of soil samples collected was 43.

Both the MSA Explosimeter and the HNu were used to monitor borehole atmosphere during drilling. The readings have been reported in the borehole logs in Appendix D. No explosimeter readings above background levels were registered in any of the boreholes. The HNu was used to measure both borehole atmosphere and vapor concentrations in individual sample atmospheres. The results are summarized in Table 4-3. The only significant HNu readings were registered in BB-5, both in the borehole atmosphere and in individual samples. The HNu readings for this boring are on the same order of magnitude as those measured in all borings at Site No. 5, Fire Protection Training Area No. 2. These instruments are used only as field diagnostic tools--their responses vary widely, depending upon the volatile compound present, and these readings may not correlate directly with soil chemistry data from actual laboratory analyses.

Five samples from each borehole, or a total of 30 samples, were selected for laboratory analysis of the 32 USEPA Priority Pollutant volatile organic compounds (VOA). The detection limits and duplicate extractions and analyses were performed on five of these samples. Analytical results are summarized in Table 4-4. The results indicate that only relatively low levels of organic contaminants were present in boreholes BB-1 through BB-4, primarily chlorinated hydrocarbons on the order of 0.001 to 0.012 ug/g. Soils in boring BB-5, however, exhibited very high levels of contamination, primarily with chloro- and dichlorobenzenes on the order of 1 to 3,500 ug/g and chlorinated hydocarbons (chloroform and methylene chloride) on the order of 0.1 to 10 ug/g. These high concentrations of VOA were encountered in BB-5 at all levels sampled below a depth of 4.5 feet. BB-6, drilled just east of BB-5, also encountered very highly contaminated soils. The soil from the 0-15 foot interval exhibited chloro- and dichlorobenzene levels between 32 and 560 ug/g, and the soil from the 6-7.5 foot level was so highly contaminated with these same compounds that the Gas Chromatograph (GC) column became saturated in the analysis. The estimated concentration of all three dichlorobenzenes at this level was 10 percent, or 100,000 ppm. The uneven distribution suggests that surface spillage

TABLE 4-3

SUMMARY OF HNu MEASUREMENTS IN SOIL BORINGS,
ZONE 4, SITE 17, DRUMMED WASTE STORAGE AREA NO. 3
AND WASTE FUEL AND SOLVENT SUMPS

Borehole Number:	BB-1	BB-2	BB-3	BB-4	BB-5	BB-6
1. Range in Borehole Atmosphere	0	0	0	0	0-150	0
2. Individual Sample Readings, by Depth Interval (feet)						
0 -1.5	0	0	1	1	0	1
1.5-3.0	1	0	1	1	4	1
3.0-4.5	1	0	1	1	125	1
4.5-6.0	2	0	1	1	75	0
6.0-7.5	0	2	2	1	100	0
7.5-9.0	0	2	7	2	130	0
9.0-10.5	0	3	1	4	90	0

Note: All measurements in ppm relative to hexane.

TABLE 4-4

SUMMARY OF ZONE 4, SITE 17, SOILS ANALYSES
FOR USEPA PRIORITY POLLUTANT VOA COMPOUNDS

COMPOUND	DETECTION LIMIT SEDIMENT (ug/g)	BB-1 0.5-2'	BB-1 2.4'[1]		BB-1 4-5.5'	BB-1 6.5-8'	BB-1 8-9.5'	BB-2 3-4.5'	BB-2 4.5-6'	BB-2 6-7.5'	BB-2 7.5-9'	BB-2 9-10.5'
Chloromethane	.0008	-	-	-	-	-	-	-	-	-	-	-
Bromomethane	.0118	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	.0181	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	.0018	-	-	-	-	-	-	-	-	-	-	-
Chloroethane	.0052	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	.0025[2]	-	-	-	-	-	-	-	-	-	-	-
Trichlorofluoromethane	.010	-	-	-	-	-	-	-	-	-	-	-
1,1 Dichloroethene	.013	-	-	-	-	-	-	-	-	-	-	-
1,1 Dichloroethane	.0007	-	-	-	-	.0033	.007	-	-	-	-	-
Trans 1,2 Dichloroethene	.001	-	-	-	-	.011	.003	-	-	-	-	-
Chloroform	.0005	-	-	-	-	.0017	.0045	-	-	-	-	-
1,2 Dichloroethane	.0003	-	-	-	-	.0053	.0082	-	-	-	-	-
1,1,1-Trichloroethane	.0003	-	-	-	-	-	-	-	-	-	-	-
Carbon tetrachloride	.0012	-	-	-	-	-	-	-	-	-	-	.0014
Bromodichloromethane	.001	-	.001	-	-	-	-	-	-	-	-	-
1,2 Dichloropropane	.0004	-	-	-	-	-	-	-	-	-	-	-
Trans 1,3-Dichloropropene	.0034	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	.0012	-	-	-	-	-	-	-	-	-	-	-
Dibromochloromethane	.0009	-	-	-	-	-	-	-	-	-	-	-
1,1,2 Trichloroethylene	.0002	-	-	-	-	-	-	-	-	-	-	-
Cis 1,3-Dichloropropene	.002	-	-	-	-	-	-	-	-	-	-	-
2-Chloroethylvinylether	.0013	-	-	-	-	-	-	-	-	-	-	-
Bromoform	.002	-	-	-	-	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	.0003	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	.0003	-	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	.0025	-	-	-	-	-	-	-	-	-	-	-
1,3 Dichlorobenzene	.0032	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichlorobenzene	.0015	-	-	-	-	-	-	-	-	-	-	-
1,4 Dichlorobenzene	.0024	-	-	-	-	-	-	-	-	-	-	-
Benzene	.1	-	-	-	-	-	-	-	-	-	-	-
Toluene	.1	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	.1	-	-	-	-	-	-	-	-	-	-	-
Number of unidentified peaks		0	0	0	0	0	0	0	0	0	0	0

NOTES:

- \- Compounds analyzed but not found above detection limit
- 1 Duplicate analyses
- 2 Methylene chloride values below .01 ug/g not reported
- 3 Unknown hydrocarbon mixture present in sample
- 4 Column saturated (estimated concentration:10%)

TABLE 4-4 (Cont.)

SUMMARY OF ZONE 4, SITE 17, SOILS ANALYSES
FOR USEPA PRIORITY POLLUTANT VOA COMPOUNDS

COMPOUND	DETECTION LIMIT SEDIMENT (ug/g)	BB-3 3-4.5'[1]		BB-3 4.5-6'	BB-3 6-8'	BB-3 8-9.5'	BB-3 9.5-11'	BB-4 3-4.5'	BB-4 4.5-6'	BB-4 6-7.5'	BB-4 7.5-9'	BB-4 9-10.5'
Chloromethane	.0008	–	–	–	–	–	–	–	–	–	–	–
Bromomethane	.0118	–	–	–	–	–	–	–	–	–	–	–
Dichlorodifluoromethane	.0181	–	–	–	–	–	–	–	–	–	–	–
Vinyl chloride	.0018	–	–	–	–	–	–	–	–	–	–	–
Chloroethane	.0052	–	–	–	–	–	–	–	–	–	–	–
Methylene chloride	.0025[2]	–	–	–	–	–	–	–	–	.012	–	–
Trichlorofluoromethane	.010	–	–	–	–	–	–	–	–	–	–	–
1,1 Dichloroethene	.0013	–	–	–	–	–	–	–	–	–	–	–
1,1 Dichloroethane	.0007	–	–	–	–	–	–	–	–	–	–	–
Trans 1,2 Dichloroethene	.001	–	–	–	–	–	–	–	–	–	–	–
Chloroform	.0005	–	–	–	–	–	–	–	–	–	–	–
1,2 Dichloroethane	.0003	–	–	–	–	–	–	–	–	–	–	–
1,1,1-Trichloroethane	.0003	–	–	–	–	–	–	–	–	–	–	–
Carbon tetrachloride	.0012	–	–	–	–	–	–	–	–	–	–	–
Bromodichloromethane	.001	–	–	–	–	–	–	–	–	–	–	–
1,2 Dichloropropane	.0004	–	–	–	–	–	–	–	–	–	–	–
Trans 1,3-Dichloropropene	.0034	–	–	–	–	–	–	–	–	–	–	–
Trichloroethylene	.0012	–	–	–	–	–	–	–	–	–	–	–
Dibromochloromethane	.0009	–	–	–	–	–	–	–	–	–	–	–
1,1,2 Trichloroethylene	.0002	–	–	–	–	–	–	–	–	–	–	–
Cis 1,3-Dichloropropene	.002	–	–	–	–	–	–	–	–	–	–	–
2-Chloroethylvinylether	.0013	–	–	–	–	–	–	–	–	–	–	–
Bromoform	.002	–	–	–	–	–	–	–	–	–	–	–
1,1,2,2-Tetrachloroethane	.0003	–	–	–	–	–	–	–	–	–	–	–
Tetrachloroethene	.0003	–	–	–	–	–	–	–	–	–	–	–
Chlorobenzene	.0025	–	–	–	–	–	–	–	–	–	–	–
1,3 Dichlorobenzene	.0032	–	–	–	–	–	–	–	–	–	–	–
1,2 Dichlorobenzene	.0015	–	–	–	–	–	–	–	–	–	–	–
1,4 Dichlorobenzene	.0024	–	–	–	–	–	–	–	–	–	–	–
Benzene	.1	–	–	–	–	–	–	–	–	–	–	–
Toluene	.1	–	–	–	–	–	–	–	–	–	–	–
Ethylbenzene	.1	–	–	–	–	–	–	–	–	–	–	–
Number of unidentified peaks		0	0	0	0	0	0	0	0	0	0	0

NOTES:

– Compounds analyzed but not found above detection limit
1 Duplicate analyses
2 Methylene chloride values below .01 ug/g not reported
3 Unknown hydrocarbon mixture present in sample
4 Column saturated (estimated concentration:10%)

TABLE 4-4 (Cont.)

SUMMARY OF ZONE 4, SITE 17, SOILS ANALYSES
FOR USEPA PRIORITY POLLUTANT VOA COMPOUNDS

COMPOUND	DETECTION LIMIT SEDIMENT (ug/g)	BB-5 3-4.5'[1]		4.5-6'	6-7.5'[1]		7.5-9'[1]		9-10.5'[1]	
Chloromethane	.008	-	-	-	-	-	-	-	-	-
Bromomethane	.0118	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	.0181	-	-	-	-	-	-	-	-	-
Vinyl chloride	.0018	-	-	-	-	-	-	-	-	-
Chloroethane	.0052	-	-	-	-	-	-	-	-	-
Methylene chloride	.0025[2]	-	-	.016	-	-	24.	12.	27.	27.
Trichlorofluoromethane	.010	-	-	-	-	-	-	-	-	-
1,1 Dichloroethene	.0013	-	-	-	-	-	-	-	-	-
1,1 Dichloroethane	.0007	-	-	-	-	-	-	-	-	-
Trans 1,2 Dichloroethene	.001	-	-	-	-	-	-	-	-	-
Chloroform	.0005	-	-	.0006	-	-	.142	.277	-	-
1,2 Dichloroethane	.0003	-	-	-	-	-	9.7	11.6	-	-
1,1,1-Trichloroethane	.0003	-	-	-	-	-	-	-	-	-
Carbon tetrachloride	.0012	-	-	-	-	-	-	-	-	-
Bromodichloromethane	.001	-	-	-	-	-	-	-	-	-
1,2 Dichloropropane	.0004	-	-	-	-	-	-	-	-	-
Trans 1,3-Dichloropropene	.0034	-	-	-	-	-	-	-	-	-
Trichloroethylene	.0012	-	-	-	-	-	.098	.11	-	-
Dibromochloromethane	.0009	-	-	-	-	-	-	-	-	-
1,1,2 Trichloroethylene	.0002	-	-	-	-	-	-	-	-	-
Cis 1,3-Dichloropropene	.002	-	-	-	-	-	-	-	-	-
2-Chloroethylvinylether	.0013	-	-	-	-	-	-	-	-	-
Bromoform	.002	-	-	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	.0003	-	-	-	-	-	-	-	-	-
Tetrachloroethene	.0003	-	-	-	-	-	.070	.069	-	-
Chlorobenzene	.0025	-	-	.97	-	-	3,500.	3,500.	-	-
1,3 Dichlorobenzene	.0032	-	-	-	61.	41.	24.	24.	60.	70.
1,2 Dichlorobenzene	.0015	-	-	1.8	1.9	.97	15.	15.	35.	37.
1,4 Dichlorobenzene	.0024	-	-	1.8	15.	10.	17.	17.	45.	56.
Benzene	.1	-	-	-	-	-	-	-	-	-
Toluene	.1	-	-	.6	-	-	-	-	-	-
Ethylbenzene	.1	-	-	.25	-	-	-	-	-	-
Number of unidentified peaks		0	0	6 (3)	0	0	2	3	0	0

NOTES:

1 Compounds analyzed but not found above detection limit
2 Duplicate analyses
3 Methylene chloride values below .01 ug/g not reported
4 Unknown hydrocarbon mixture present in sample
Column saturated (estimatede concentration:10%)

TABLE 4-4 (Cont.)

SUMMARY OF ZONE 4, SITE 17, SOILS ANALYSES
FOR USEPA PRIORITY POLLUTANT VOA COMPOUNDS

COMPOUND	DETECTION LIMIT SEDIMENT	BB-6				
	(ug/g)	0-1.5'	2.5-4'	6-7.5'	7.5-9'	9-10.5'
Chloromethane	.0008	-	-	-	-	-
Bromomethane	.0118	-	-	-	-	-
Dichlorodifluoromethane	.0181	-	-	-	-	-
Vinyl chloride	.0018	-	-	-	-	-
Chloroethane	.0052	-	-	-	-	-
Methylene chloride	.0025[2]	-	-	-	-	-
Trichlorofluoromethane	.010	-	-	-	-	-
1,1 Dichloroethene	.0013	-	-	-	-	-
1,1 Dichloroethane	.0007	-	-	-	-	-
Trans 1,2 Dichloroethene	.001	-	-	-	-	-
Chloroform	.0005	-	-	-	-	-
1,2 Dichloroethane	.0003	-	-	-	-	-
1,1,1-Trichloroethane	.0003	-	-	-	-	-
Carbon tetrachloride	.0012	-	-	-	-	-
Bromodichloromethane	.001	-	-	-	-	-
1,2 Dichloropropane	.0004	-	-	-	-	-
Trans 1,3-Dichloropropene	.0034	-	-	-	-	-
Trichloroethylene	.0012	-	-	-	-	-
Dibromochloromethane	.0009	-	-	-	-	-
1,1,2 Trichloroethylene	.0002	-	-	-	-	-
Cis 1,3-Dichloropropene	.002	-	-	-	-	-
2-Chloroethylvinylether	.0013	-	-	-	-	-
Bromoform	.002	-	-	-	-	-
1,1,2,2-Tetrachloroethane	.0003	-	-	-	-	-
Tetrachloroethene	.0003	-	-	-	-	-
Chlorobenzene	.0025	-	-	-	-	-
1,3 Dichlorobenzene	.0032	76.	-	(4)	-	-
1,2 Dichlorobenzene	.0015	37.	-	(4)	-	-
1,4 Dichlorobenzene	.0024	56.	-	(4)	3.7	-
Benzene	.1	-	.39	-	-	-
Toluene	.1	-	-	-	-	.097
Ethylbenzene	.1	-	-	-	-	-
Number of unidentified peaks		0	0 (3)	0	0	0 (3)

NOTES:

- 1 Compounds analyzed but not found above detection limit
- 2 Duplicate analyses
- 3 Methylene chloride values below .01 ug/g not reported
- 4 Unknown hydrocarbon mixture present in sample
- [illegible] sa[illegible]d (e[illegible]ed c[illegible] trati[illegible])

as well as sub-grade leakage is occurring at this site, and that the presence of very coarse-grained materials in the suburface may be allowing piping of subgrade leakage to depth beneath the sump without much lateral migration occurring.

Thirty of the same samples analyzed for VOA were also analyzed for phenolic compounds, and duplicate analyses were performed on six samples. The eleven compounds analyzed and corresponding detection limits are listed in Table 4-5. None of the phenolic compounds were detected in any of the samples analyzed.

4.4.2 Groundwater Results

A total of 22 monitor wells were installed in six Zones. They were sampled once during a single round between 5 and 12 July 1984. Due to a problem in meeting holding times, the monitor wells were resampled for oil and grease analyses in late October 1984. This section reviews the results of field measurements of pH and specific conductance and laboratory analysis results on a suite of inorganic and organic parameters. These results are summarized for the VOA compounds (including MEK, which was analyzed in all groundwater samples) in Table 4-6, and for all other parameters analyzed in Table 4-7. Complete analytical reports are provided in Appendix K. Due to the presence of laboratory contamination in blanks, measured values of methylene chloride were adjusted by subcontracting 0.0018 mg/l, and measured values of chloroform below 0.030 ppb were not reported in Table 4-6. Second column confirmation analyses were performed in accordance with EPA standard methods 601 and 602 on the nine groundwater samples exhibiting the highest levels of VOA compounds (see analyst's note at the end of Appendix K). Due to matrix interferences, required detection limits for metals and one anion could not be met--arsenic, cadmium and cyanide. For some analytes the correlation between analyses of samples and QA duplicates was only fair.

At the time of groundwater sampling, sampling of the final rinse water for equipment decontamination was also collected and labelled FB-1. This water was taken from the Base Medical Laboratory, after it had passed through a deionizing apparatus. Sample FB-1 was collected directly into clean vials and bottles from the deionized water tap, without being passed over any field equipment, and subjected to the same analyses as groundwater. Of the 32 USEPA VOA compounds plus MEK, only trichloroethylene (TCE) was detected in this water at a concentration of 0.007 mg/l.

TABLE 4-5

SUMMARY OF DETECTION LIMITS FOR PHENOLS IN SOIL SAMPLES

Compound	Detection Limit in mg/L
2-Chlorophenol	13
2-Nitrophenol	13
Phenol	13
2,4-Dimethylphenol	13
2,4-Dichlorophenol	13
2,4,6-Trichlorophenol	40
4-Chloro-3 Methylphenol	60
2,4-Dinitrophenol	40
2-Methyl-4,6 Dinitrophenol	60
Pentachlorophenol	60
4-Nitrophenol	60

TABLE 4-6

SUMMARY OF GROUNDWATER ANALYSES RESULTS
FOR USEPA PRIMARY POLLUTANT VOA COMPOUNDS AND MEK

COMPOUND	DETECTION LIMIT ug/l	Zone 1 Golf Course Waste Management Zone									Zone 2 Landfill Waste Management Zone			
		MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-11	MW-11[(1)] (MW-23)	MW-12	MW-13
Chloromethane	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromomethane	1.18	-	-	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	1.81	-	-	-	-	-	-	-	-	-	-	-	-	-
Vinyl chloride	0.18	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroethane	0.52	-	-	-	-	-	-	-	-	-	-	-	-	-
Methylene chloride	0.25	1.2	-	1.2	-	1.9	-	-	-	-	-	0.7	-	-
Trichlorofluoromethane	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1 Dichloroethene	0.13	-	-	0.30	-	-	-	-	-	-	-	-	-	-
1,1 Dichloroethane	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-
Trans 1,2 Dichloroethene	0.10	-	0.53	-	-	-	-	-	-	-	-	-	-	-
Chloroform	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichloroethane	0.03	-	0.12	-	-	-	-	-	-	-	-	-	-	-
1,1,1-Trichloroethane	0.03	-	-	-	-	-	-	-	-	-	0.10	-	-	-
Carbon tetrachloride	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromodichloromethane	0.10	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichloropropane	0.04	-	0.52	-	-	-	-	-	-	-	-	-	-	-
Trans 1,3-Dichloropropene	0.34	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	0.12	-	1.1	-	0.70	-	-	0.59	-	-	-	1.1	-	-
Dibromochloromethane	0.09	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1,2 Trichloroethylene	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-
Cis 1,3-Dichloropropene	0.20	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Chloroethylvinylether	0.13	-	-	-	-	-	-	-	-	-	-	-	-	-
Bromoform	0.20	-	-	-	-	-	-	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	0.03	-	-	-	-	-	-	-	0.04	-	5.0	4.9	0.93	2.0
Chlorobenzene	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-
1,3 Dichlorobenzene	0.32	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichlorobenzene	0.15	-	-	-	-	-	-	-	-	-	-	-	-	-
1,4 Dichlorobenzene	0.24	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Methyl Ethyl Ketone	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Peaks		1	0	0	0	0	1	3	0	0	2	2	2	1

NOTES:

- Compound analyzed but not found above detection limit
(1) Field Duplicate Sample

TABLE 4-6 (Cont.)

SUMMARY OF GROUNDWATER ANALYSES RESULTS
FOR USEPA PRIMARY POLLUTANT VOA COMPOUNDS AND MEK

		Zone 3 u/g Waste Oil Storage Tank	Zone 4 WTP Waste Management Zone				Zone 5 Waste Pit No.4	AAVS/DAVA Evaporation Ponds				
COMPOUND	DETECTION LIMIT ug/l	MW-15	MW-10	MW-20	MW-21	MW-22	MW-14	MW-16	MW-16 (1)	MW-17	MW-18	MW-19
Chloromethane	0.08	-	-	-	-	-	-	-	-	-	-	-
Bromomethane	1.18	-	-	-	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	1.81	-	-	-	-	-		-	-	-	-	-
Vinyl chloride	0.18	-	-	-	-	-	-	96	130	310	450	-
Chloroethane	0.52	3.0	-	-	-	-	-	-	-	-	-	-
Methylene chloride	0.25	-	-	0.4	-	0.5	1.6	0.9	2.1	1.2	-	0.3
Trichlorofluoromethane	1.0		-	-	-	-	-	-		-	-	-
1,1 Dichloroethene	0.13	1.5	-	-	-	-	-	0.60	-	-	-	-
1,1 Dichloroethane	0.07	0.71	-	-	-	-	-	0.30	-	-	-	-
Trans 1,2 Dichloroethene	0.10	420	-	-	-	-	3.0	200	149	22	11	1.2
Chloroform	0.05	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichloroethane	0.03	-	-	-	-	-	-	-	-	-	-	-
1,1,1-Trichloroethane	0.03	-	1.1	-	-	-	-	-	-	-	-	-
Carbon tetrachloride	0.12	-	-	-	-	-	-	-	-	-	-	-
Bromodichloromethane	0.10	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichloropropane	0.04	-	-	-	-	-	-	-	-	-	-	-
Trans 1,3-Dichloropropene	0.34	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	0.12	1,000	40	-	0.16	-	230	-	0.24	-	-	0.56
Dibromochloromethane	0.09	-	-	-	-	-	-	-	-	-	-	-
1,1,2 Trichloroethylene	0.02	-	-	-	-	-	-	-	-	-	-	-
Cis 1,3-Dichloropropene	0.20	-	-	-		-	-	-	-	-	-	-
2-Chloroethylvinylether	0.13	-	-	-	-	-	-	-	-	-	-	-
Bromoform	0.20	-	-	-	-	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	0.03	-	-	-	-	-		-	-	-	-	-
Tetrachloroethene	0.03	0.10	0.13	-	0.04	-	-	-	-	-	-	0.50
Chlorobenzene	0.25	-	-	-	-	-	-	3.0	2.9	1.1	0.50	-
1,3 Dichlorobenzene	0.32	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichlorobenzene	0.15	-	-	-	-	-	-	-	-	-	-	-
1,4 Dichlorobenzene	0.24	-	-	-	-	-	-	3.0	5.4	2.9	1.4	0.52
Benzene	10	65	-	-	-	-	-	-	-	-	-	-
Toluene	10	640	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	10	41	-	-	-	-	-	-	-	-	-	-
Methyl Ethyl Ketone	10	43	-	-	-	-	12	-	-	-	-	-
Unidentified Peaks			2	0	0	2	2	5	6	5	3	2

NOTES:

- \- Compound analyzed but not found above detection limit
- (1) Field Duplicate Sample

TABLE 4-7: SUMMARY OF GROUNDWATER ANALYSES, NORTON AFB

ZONE 1

GOLF COURSE WASTE MANAGEMENT ZONE

	Detection Limit In Water	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-24[1]	MW-7	MW-8	MW-9
pH		6.81	7.17	7.81	7.21	7.11	7.41		7.30	7.27	7.26
Specific Conductance (umhos/cm)		6.74	510	1480	514	584	814		659	500	684
Metals (mg/L)											
Lead	0.05	--	--	--	0.43	--	--	--	--	--	0.10
Chromium	0.05	--	--	--	--	--	--	--	--	--	--
Nickel	0.10	--	--	--	--	--	--	--	--	--	--
Cadmium	0.05	--	--	--	--	--	--	--	--	--	--
Arsenic	0.10	--	--	--	--	--	--	--	--	--	--
Zinc	0.02	--	--	--	--	--	--	--	--	--	--
Copper	0.03	--	--	--	--	--	--	--	--	--	--
Mercury	0.0005	--	--	--	--	--	--	--	--	--	--
Lithium	1.0	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Cyanide (mg/L)	0.03	NR	NR	NR	NR	NR	NR	NR	NR	--	NR
Phenol (mg/L)	0.005	0.043	0.044	0.036	0.064	NR	NR	NR	NR	0.036	NR
Oils and Greases (mg/L)	0.6	1.1	0.8	2.0	0.8	3.0	1.0	2.7[1]	4.0	4.0	7.2
TOC (mg/L)	1.0	6.3	2.8	2.4	--	2.3	9.7	1.7	--	2.3	4.1
TOX (mg/L)	0.005	0.018	0.023	0.011	0.027	0.014	0.006	0.013	--	0.048	0.014

-- Compound analyzed but not found above detection limit.
NR Analysis not required by Task Order.
(1) Field duplicate of MW- 6.

TABLE 4-7: SUMMARY OF GROUNDWATER ANALYSES, NORTON AFB

	Detection Limit In Water	ZONE 2 LANDFILL WASTE MANAGEMENT ZONE				ZONE 3 UNDERGROUND WASTE OIL STORAGE TANK	ZONE 4 IWTP WASTE MANAGEMENT ZONE			
		MW-11	MW-23.[1]	MW-12	MW-13	MW-15	MW-10	MW-20	MW-21	MW-22
pH		6.88		6.97	6.94	7.02	7.01	7.24	7.40	6.87
Specific Conductance (umhos/cm)		342		251	365	1177	525	464	366	802
Metals (mg/L)										
Lead	0.05	--	0.06	0.05	--	--	--	--	--	--
Chromium	0.05	--	--	--	--	--	--	--	--	--
Nickel	0.10	--	--	--	--	--	--	--	--	--
Cadmium	0.05	--	--	--	--	--	--	--	--	--
Arsenic	0.10	--	--	--	--	--	0.354	--	--	--
Zinc	0.02	--	--	--	--	--	--	--	--	--
Copper	0.03	--	--	--	--	--	--	--	--	--
Mercury	0.0005	--	--	--	--	--	--			
Lithium	1.0	--	--	--	--	NR	NR	NR	NR	NR
Cyanide (mg/L)	0.03	NR	NR	NR	NR	NR	NR	NR	NR	NR
Phenol (mg/l)	0.005	NR	NR	NR	NR	NR	NR	NR	NR	NR
Oils and Greases (mg/L)	0.6	20	12[1]	3.0	3.6	3.6	3.0	1.0	1.0	1.0/2.0[1]
TOC (mg/L)	1.0	--	--	5.5	3.5	41.6	4.0	3.8	--	(2)
TOX (mg/L)	0.005	0.014	0.034	--	0.007	0.288	0.027	0.125	0.013	0.033

-- Compound analyzed but not found above detection limit.
NR Analysis not required by Task Order.
(1) Field duplicate of MW-11.
(2) Sample container lost or broken.

TABLE 4-7: SUMMARY OF GROUNDWATER ANALYSES, NORTON AFB

	DETECTION LIMIT IN WATER	ZONE 5 WASTE PIT NO. 4	ZONE 6 AAVS/DAVA EVAPORATION PONDS				
		MW-14	MW-16	MW-25 (1)	MW-17	MW-18	MW-19
pH		6.75	6.53		6.65	6.59	6.47
Specific Conductance (umhos/cm)		1053	1637		782	627	423
Metals (mg/L)							
Lead	0.05	0.07		--	--	0.06	--
Chromium	0.05	--	--	--	--	--	--
Nickel	0.10	--	--	--	--	--	--
Cadmium	0.05	--	--	--	--	--	--
Arsenic	0.10	--	--	--	--	--	--
Zinc	0.02	--	--	--	--	--	--
Copper	0.03	--	--	--	--	--	--
Mercury	0.0005	--	--	--	--	--	--
Lithium	1.0	NR	NR	NR	NR	NR	NR
Cyanide (mg/L)	0.03	NR	--	--	--	--	--
Phenol (mg/L)	0.005	NR	NR	NR	NR	NR	NR
Oils and Greases (mg/L)	0.6	2.0	1.4	4.6 (1)	--	0.9	0.8
TOC (mg/L)	1.0	--	14.1	13.7	18.1	10.8	3.5
TOX (mg/L)	0.005	0.127	0.145	0.119	0.094	0.051	0.071

-- Compound analyzed but not found above detection limit.
NR Analysis not required by Task Order.
(1) Field duplicate of MW-16.

4.4.2.1 Zone 1 - Groundwater Quality

Nine monitor wells (MW-1 through MW-9) were drilled in Zone 1, the Golf Course Waste Management Zone, in locations presumed to be downgradient (MW-1, MW-2 and MW-3) and along the Base boundary (MW-4 through MW-9). MW-1 and MW-3 are finished in a shallow water-table zone, MW-2 and MW-4 through MW-9 in a slightly deeper semi-confined zone. Samples were collected from all 9 wells, and a field duplicate for inorganics in MW-6 (labeled MW-24) was also collected.

Values of pH in all nine wells were in the normal range (6.9 to 7.4), and values of specific conductance (SC) were somewhat elevated (514 to 814 umhos/cm), most likely due to elevated levels of inorganic salts in natural groundwater related to the semi-arid climate. A single well, MW-3, had an anomalously high SC of 1480 umhos/cm. Of the dissolved metals analyzed for, only lead was detected in two of the nine wells. In MW-9, the value measured was twice the Federal Primary Drinking Water Standard (FPDWS) of 0.05 mg/L. In one well, MW-4, an elevated lead value of 0.43 mg/L was encountered.

A cyanide analysis was required by the Task Order in only one well in this Zone, MW-18, and it was not found above the detection limit in this well.

Phenol analyses were require. at only five wells in this Zone (MW-1 through MW-4 and MW-8). Phenol was found consistently at concentrations varying from 0.036 to 0.064 mg/l. This range is well above the taste and odor threshhold guideline of 0.001 mg/l.

TOC concentration ranged from below detection limit (1.0 mg/l) to 9.7 mg/l, with the highest value exhibited in MW-6. TOX values ranged from below detection limit (0.005 mg/L) to 0.048 mg/l with the highest value exhibited in MW-8.

Of the 32 USEPA VOA compounds plus MEK, none were detected in two of the wells (MW-6 and MW-9), and those detected in the remaining wells (including methylene chloride, 1,1-dichloroethane and TCE) occurred at levels only slightly above detection limits, in the range of 0.0012 to 0.0019 ug/L. Unidentified peaks were detected in three wells: MW-1, MW-6 and MW-7.

4.4.2.2 Zone 2 - Groundwater Quality

Three monitor wells (MW-11, MW-12 and MW-13) were drilled in Zone 2, the Landfill Waste Management Zone, in the presumed

downgradient direction. Based on the groundwater flow analysis, the predominant flow direction for this area is to the west and the monitor well locations are actually cross-gradient, with MW-11 being the most downgradient. These well locations were constrained by field access and by subsurface conditions encountered. Samples were collected from all three wells, and a field duplicate of MW-11 (labeled MW-23) was also collected.

Values of pH in this Zone are in the normal range (6.88 to 6.94) and very slightly more acidic than those in Zone 1. The field specific conductance of the samples ranged from 251 to 365 umhos/cm, somewhat lower than in Zone 1, and probably represent background conditions for the Base.

Of the eight standard dissolved metals analyzed for (Pb, Cr, Ni, Cd, As, Zn, Cu, Hg), only lead was detected at or near the FPDWS of 0.05 mg/l in Wells MW-11 and MW-12. The Task Order called for an additional analysis for lithium in these wells due to the reported presence of a disposal pit for lithium batteries just west of the main landfill area. No dissolved lithium was detected in any of the three well analyses nor in the duplicate for MW-11.

TOC values ranged from below detection limit (1.0 mg/L) to 5.5 mg/l, with the higher value exhibited in the duplicate of MW-11.

Of the 32 USEPA VOA compounds plus MEK, only TCE was detected (at the relatively low levels of 0.0009 and 0.002 mg/l) in MW-12 and MW-13. In MW-11, TCE was found at an average level of approximately 0.005 mg/l. Three other compounds detected occurred at relatively low levels (0.0001 to 0.0011 mg/l) and were not confirmed between the two duplicate samples. Unidentified peaks were detected in all samples, one in MW-13 and two each in MW-11 and MW-12.

4.4.2.3 Zone 3 - Groundwater Quality

A single monitor well, MW-15, was drilled in the vicinity of Site 6, the Underground Waste Oil Storage Tank, in the presumed downgradient direction. A single sample was collected from this well. An oily product was observed in an emulsion in the portion of the sample collected from the top of the water column for oil and grease analysis.

Measured field pH was approximately neutral (7.02), and the field SC somewhat elevated (1177 umhos/cm). None of the requested dissolved metals were found above detection limits.

The TOC concentration in this well was 41.6 mg/L, and the TOX was 0.288 mg/L. Both concentrations are relatively high, approximately one order of magnitude higher than concentrations for the same parameters in Zones 1 and 2.

Of the 32 USEPA VOA compounds plus MEK, ten were detected in MW-15. The following compounds were found above a value of 10 ug/L: trans 1,2-dichloroethane (0.420 mg/l), TCE (1.0 mg/l), benzene (0.165 mg/l), toluene (1.64 mg/L), ethylbenzene (0.041 mg/L) and MEK (0.043 mg/L). These levels indicate contamination in the Zone with both fuel derivatives and solvents. Two unidentified peaks were detected in the sample from MW-15.

These results confirm HNu readings made in the field. Of all the monitor wells drilled, MW-15 was the only well in which detectable HNu readings were measured. HNu readings of split-spoon sample headspace were zero down to the water-table. Below a level of 35 feet, three readings were taken ranging from 4 to 20 ppm.

4.4.2.4 Zone 4 - Groundwater Quality

Four monitor wells were drilled in Zone 4, the IWTP Waste Management Zone: MW-10, MW-20, MW-21 and MW-22. All four wells are screened in the shallow water-table aquifer, and the direction of groundwater flow is currently undetermined.

Values of pH encountered were in the normal range (6.87 to 7.40), and SC values in this zone were comparable to Zone 1, ranging from 366 to 802 umhos/cm.

Of the eight standard dissolved metals, only arsenic was detected in one well, MW-10, at a concentration of 0.354 mg/l. This is over seven times the FPDWS of 0.05 mg/l.

TOC values ranged from below detection level (1.0 mg/l) to 4.0 mg/l, with the highest value in MW-10. TOX ranged from 0.013 to 0.125 mg/l, with the highest value in MW-20.

Of the 32 USEPA VOA compounds plus MEK, four were detected at this site, generally in concentrations below 0.0011 mg/l. In well MW-10, however, TCE was detected at a level of 0.040 ug/L. Two unidentified peaks were detected in both MW-10 and MW-22.

4.4.2.5 Zone 5 - Groundwater Quality

A single monitor well was drilled in Zone 5, adjacent to Site 14, Waste Pit No. 4: MW-14. A single groundwater sample was collected from this well.

Measured field pH in this well was in the normal range (6.75), and the field SC was elevated (1053 umhos/cm). Of the requested dissolved metals, only lead was detected, at a level of 0.07 mg/l.

The reported value of TOC in this well was below the detection limit of 1.0 mg/l, but the TOX level was relatively high (0.127 mg/l).

Of the 32 USEPA VOA compounds plus MEK, four were detected, including two at excessive concentrations: TCE (0.230 ug/L) and MEK (0.012 ug/L). Both of these are solvents commonly used as paint thinners and strippers. Two unidentified peaks were detected in the sample from MW-14.

4.4.2.6 Zone 6 - AAVS/DAVA Evaporation Basins

Four wells (MW-16 through MW-19) were drilled adjacent to this site, including one upgradient well (MW-19). All four are screened in the principal aquifer, which is unconfined in this area. According to the groundwater flow analysis, MW-16 and MW-17 are directly downgradient of the site. Five groundwater samples were collected in this Zone, including one field duplicate of MW-16 (labelled MW-25).

Field pH values were in the normal range (6.47-6.65) and slightly more acidic than the other Zones. Specific conductance was 423 umhos/cm in the upgradient well, and 627, 782 and 1637 umhos/cm respectively in downgradient wells MW-18, MW-17 and MW-16.

Of the eight standard dissolved metals only lead was found at a level of 0.06 mg/l in MW-18. Cyanide was analyzed for but not detected in any of the groundwater samples from this Zone.

TOC values were relatively low in MW-19 (3.5 mg/l) and somewhat elevated (10.8 to 18.1 mg/l) in the other wells. TOX values ranged from 0.051 and 0.071 mg/l in MW-18 and MW-19 respectively to 0.119 and 0.145 mg/l in the two duplicate samples from MW-16.

Of the 32 USEPA VOA compounds plus MEK, five were detected in MW-19 at relatively low concentrations (0.0003 to 0.0012 mg/l). Eight were detected in the duplicates for MW-16, of which four were confirmed between the two samples and occurred also in MW-17 and MW-18: vinyl chloride (0.096 to 0.450 mg/l), (trans)1,2-dichloroethylene (0.0011 to 0.20 mg/l), chlorobenzene (0.0005 to 0.003 mg/l) and 1,2-dichlorobenzene (0.0014 to 0.0054 mg/l). Five and six unidentified peaks were detected in the two duplicates of MW-16, five in MW-17, three in MW-18 and two in MW-19.

4.4.3 Pond Results

Three Golf Course Ponds were sampled, primarily to assess the degree of environmental degradation that might have occurred in surface water bodies on the Golf Course related to the presence of old disposal areas. Pond 1 is an irrigation reservoir for the golf course. It is lined with cement and is refilled with drinking water from the Base supply. It is located approximately at the site of Waste Pit No. 1 (Site 4). Ponds 2 and 3 are shallow stagnant ponds adjacent to each other, with some degree of communication between the two. They are located approximately on the sites of the old industrial waste lagoons (site No. 1). Between 5 and 8 July 1984, samples of surface water, bottom sediment and fish tissue were collected at these ponds, in locations shown in Figure 3-15. Results of all chemical analyses on pond samples are summarized in Tables 4-8 and 4-9.

4.4.3.1 Surface Water Results

A total of three surface water samples were collected, one from each pond. These samples were analyzed for essentially the same parameters as groundwater (Table 3-2), including the same eight dissolved metals. Results are summarized in Tables 4-8 and 4-9.

Pond water pH values ranged from 8.1 in Pond 1 to 9.10 and 9.22 in Ponds 2 and 3, respectively, and are significantly more basic than groundwater in the area. SC values were 260 umhos/cm in Pond 1, 814 and 376 umhos/cm, respectively, in Ponds 2 and 3.

Of the eight dissolved metals, only lead was detected, at a level of 0.09 mg/l in water from Pond 3.

TABLE 4-8: SUMMARY OF POND SURFACE WATER, BOTTOM SEDIMENT AND FISH TISSUE ANALYSES, NORTON AFB

	Detection Limit In Water (mg/L)	POND WATER (mg/L)			Detection Limit In Sediment (ug/g)	POND BOTTOM SEDIMENT (ug/g)			
		POND 1	POND 2	POND 3		POND 1	POND 1 (1)	POND 2	POND 3
pH		8.5	9.10	9.22					
Specific Conductance (umho/cm)		260	814	376					
Metals									
Lead	0.05	--	--	0.09		NR	NR	NR	NR
Chromium	0.05	--	--	--		NR	NR	NR	NR
Nickel	0.10	--	--	--		NR	NR	NR	NR
Cadmium	0.05	--	--	--		NR	NR	NR	NR
Arsenic	0.10	--	--	--		NR	NR	NR	NR
Zinc	0.02	--	--	--		NR	NR	NR	NR
Copper	0.03	--	--	--		NR	NR	NR	NR
Mercury	0.0005	--	--	--		NR	NR	NR	NR
Cyanide	0.03	NR	NR	NR		NR	NR	NR	NR
Phenol	0.005	0.041	0.043	0.041	0.010	--	0.038	0.012	--
Oil and Grease	0.1					NR	NR	NR	NR
TOC	1.0	--	5.1	2.1		NR	NR	NR	NR
TOX	0.005	0.020	0.022	0.020		NR	NR	NR	NR

-- Compound analyzed but not found above detection limit.

NR Analysis not required by Task Order.

(1) Field duplicate

TABLE 4-8: SUMMARY OF POND SURFACE WATER, BOTTOM SEDIMENT AND FISH TISSUE ANALYSES, NORTON AFB

	Detection Limit In Fish Tissue (ug/g)	POND FISH TISSUE (ug/g)				
		Pond 1 F1	Pond 1 F2	Pond 2 F1	Pond 2 F2	Pond 3 F1
pH						
Specific Conductance (umho/cm)						
Metals						
Lead	0.5	--	--	--	--	--
Chromium	0.05	0.50	0.50	0.38	0.79	0.72
Nickel	0.1	--	1.2	--	--	--
Cadmium	0.05	--	--	0.50	--	0.50
Arsenic	0.01	--	--	--	--	--
Zinc	0.03	40.0	37.2	34.4	201	37.9
Copper	0.02	2.0	4.8	2.5	2.7	2.5
Mercury	0.001	0.03	--	--	--	--
Lithium						
Cyanide						
Phenol						
Oil and Grease						
TOC						
TOX						

-- Compound analyzed but not found above detection limit.

NR Analysis not required by Task Order.

(1) Field duplicate

TABLE 4-9

SUMMARY OF POND SURFACE WATER AND BOTTOM SEDIMENT ANALYSES RESULTS FOR USEPA PRIORITY POLLUTANT VOA COMPOUNDS AND MEK

COMPOUND	DETECTION LIMIT IN WATER (ug/L)	Pond Water			DETECTION LIMIT IN SEDIMENT (ug/g)	Pond Bottom Sediment			
		Pond 1	Pond 2	Pond 3		Pond 1	Pond 1(1)	Pond 2	Pond 3
Chloromethane	0.08	-	-	-	.0008	-	-	-	-
Bromomethane	1.18	-	-	-	.0118	-	-	-	-
Dichlorodifluoromethane	1.81	-	-	-	.0181	-	-	-	-
Vinyl chloride	0.18	-	-	-	.0018	-	-	-	-
Chloroethane	0.52	-	-	-	.0032	-	-	-	-
Methylene chloride	0.25	-	-	-	.00255	-	-	-	-
Trichlorofluoromethane	1.0	-	-	-	.010	-	-	-	-
1,1 Dichloroethene	0.13	-	-	-	.0013	-	-	-	-
1,1 Dichloroethane	0.07	-	-	-	.0007	-	-	-	-
Trans 1,2 Dichloroethene	0.10	-	-	-	.001	0.14	0.11	1.1	1.2
Chloroform	0.05	-	-	-	.0005	-	-	-	-
1,2 Dichloroethane	0.03	-	-	-	.0003	-	-	-	-
1,1,1-Trichloroethane	0.03	-	-	-	.0003	-	-	-	-
Carbon tetrachloride	0.12	-	-	-	.0012	-	-	-	-
Bromodichloromethane	0.10	-	-	-	.001	-	-	-	-
1,2 Dichloropropane	0.04	-	-	-	.0004	-	-	-	-
Trans 1,3-Dichloropropene	0.34	-	-	-	.0034	-	-	-	-
Trichloroethylene	0.12	0.13	-	-	.0012	-	-	0.40	-
Dibromochloromethane	0.09	-	-	-	.0009	-	-	-	-
1,1,2 Trichloroethylene	0.02	-	-	-	.0002	-	-	-	-
Cis 1,3-Dichloropropene	0.20	-	-	-	.002	-	-	-	-
2-Chloroethylvinylether	0.13	-	-	-	.0013	-	-	-	-
Bromoform	0.20	-	-	-	.002	-	-	-	-
1,1,2,2-Tetrachloroethane	0.03	-	-	-	.0003	-	-	-	-
Tetrachloroethene	0.03	-	-	-	.0003	-	-	-	-
Chlorobenzene	0.25	-	-	-	.0025	-	-	-	-
1,3 Dichlorobenzene	0.32	-	-	-	.0032	-	-	-	-
1,2 Dichlorobenzene	0.15	-	-	-	.0015	-	-	-	-
1,4 Dichlorobenzene	0.24	-	-	-	.0024	-	-	-	-
Benzene	10	-	-	-	.1	-	-	-	-
Toluene	10	-	-	-	.1	-	-	-	-
Ethylbenzene	10	-	-	-	.1	-	-	-	-
Methyl Ethyl Ketone	10	-	-	-	.1	-	-	-	-
Number of Unidentfied Peaks		3	1	1		1	0	1	2

NOTES:

- Compound analyzed but not found above detection limit
(1) Field Duplicate Sample

Phenol levels in all three ponds ranged from 0.041 to 0.043 mg/l, in the same order as groundwater in Zone 1.

TOC levels were undetected in Pond 1, 5.1 mg/l in Pond 2, and 2.1 mg/l in Pond 3. TOX concentrations were approximately equal (0.02 mg/l) in all three ponds.

None of the 32 USEPA VOA compounds or MEK were detected in any of the ponds, except TCE at a concentration of 0.0013 mg/l in Pond 1. This is on the same order as TCE found in the medical lab deionized water (FB-1) measured at a level of 0.0069 mg/l.

4.4.3.2 Bottom Sediment Results

Four bottom sediment samples were collected from the Ponds: two duplicates from the site of Pond 1 just below water level, and one each from the approximate centers of Ponds 2 and 3. These samples were analyzed for phenol and VOA compounds.

Phenol results in sediment did not appear to be highly reproducible. They were below the detection limit of 0.001 ug/g in one sample from Pond 1 and 0.038 ug/g in the duplicate from Pond 1. Values reported for Ponds 2 and 3 were 0.012 ug/g and below detection limit, respectively.

Of the 32 USEPA VOA compounds plus MEK, only trans 1,2-dichloroethane was detected consistently in all three ponds, at an average concentration of 0.0013 ug/g in Pond 1, and at 0.0011 and 0.0012 ug/g in Ponds 2 and 3, respectively. TCE was detected in Pond 2 at a level of 0.0004 ug/g.

4.4.3.3 Fish Tissue Results

Five fish tissue samples from three ponds were collected, as summarized in Table 3-8, and analyzed for the following metals: Pb, Cr, Ni, Cd, As, Zn, Cu, Hg. Results of the metal analyses on fish tissue samples are given in Table 4-8.

Neither arsenic nor lead was present at the detection levels of the analyses. Nickel, cadmium and mercury were present at relatively low levels in only one or two of the five samples. Chromium, zinc and copper were found in all samples at concentrations ranging from 0.38 to 0.79 ug/g,

37.2 to 20.1 ug/g and 2.0 to 4.8 ug/g by dry weight, respectively.

4.5 SIGNIFICANCE OF FINDINGS

4.5.1 Soil Quality

4.5.1.1 Soil Quality - General

Other than the USEPA Action Level of 50 ug/g for PCB in soil, there are no current quality standards, guidelines or criteria for the majority of soil contaminants. Target concentrations for various compounds in soils are usually established on a case-by-case basis by the regulatory agency having jurisdiction, and these target concentrations are usually established for attainment purposes in cleanup of environmental contamination.

4.5.1.2 Zone 1, Site 5, Fire Protection Training Area No. 2

Soil contaminated with volatile organic compounds was encountered in all six boreholes drilled on the perimeter of this site, down to a depth of at least six feet. Primary contaminants were fuel derivatives (benzenes, toluene and ethylbenzene) found in concentrations ranging up to 10 ug/g. Secondary contaminants included chlorinated hydrocarbons [such as (trans) 1,2-dichloroethane, trichloroethylene, and tetrachloroethylene] found at concentrations up to 0.150 ug/g. These are significant levels for soil, and are of potential concern in terms of groundwater quality in the aquifer(s) underlying the site.

4.5.1.3 Zone 4, Site 17, Drummed Waste Storage Area No. 3 and Waste Fuel and Solvent Sumps

Soil contaminated by volatile organic compounds was found in the two boreholes south of the Waste Fuel and Solvent Sump (BB-5 and BB-6). High concentrations were found at all levels in BB-5, with the highest concentrations in both boreholes occurring at a level of 6 to 9 feet below ground surface. Primary contaminants were chloro- and dichlorobenzene, found at a maximum concentration high in the 6 to 7.5 foot sample from BB-6 that the GC column was saturated. Secondary contaminants were methylene chloride (12 to 23 ug/g) and 1,2-dichloroethane (9.7 to 11.6 ug/g). The levels of soil contamination encountered at this site

were very high and are considered to be of immediate concern relative to groundwater beneath this site, particularly given the proximity of this site to a public water supply well field (Figure 2-6).

4.5.2 Groundwater Quality

4.5.2.1 Water Quality - General

The principal objective of the Phase II Confirmation Study was to determine whether past hazardous waste operations or disposal practices had resulted in environmental degradation. The analytical results of the Phase II study represent a single round of sampling of selected leachate seeps and newly installed monitor wells. The conclusions drawn from this information should be evaluated with this understanding.

Groundwater and leachate water quality results are presented in Tables 4-1, 4-2, 4-3 and 4-4. Appendix H includes all analytical results from monitoring the Phase II sites. Appendix L contains a complete listing of Federal and State drinking water and human health standards.

On 12 June 1984, the U.S. Environmental Protection Agency published a set of proposed rules under the Safe Drinking Water Act that would establish Recommended Maximum Contaminant Levels (RMCLs) for the following volatile synthetic organic chemicals (VOC's) in drinking water: tri-chloroethylene; tetrachloroethylene; carbon tetrachloride; 1,1,1-trichloroethane; vinyl chloride; 1,2-dichloroethane; benzene; 1,1-dicholroelthylene; and p-dichlorobenzene.

RMCLs are non-enforceable health goals which are to be set at levels which would result in no known or anticipated adverse health effects with an adequate margin of safety. This proposal is the initial stage of rule-making for the establishment of primary drinking water regulations for the nine VOC's. Following this proposal, Maximum Contaminant Levels (MCLs) and monitoring/reporting requirements will be proposed when the RMCLs are promulgated. MCLs will be enforceable standards and are to be set as close to the RMCLs as is feasible and are based upon health, treatment technologies, cost and other factors. It is anticipated that RMCLs for most of the above compounds would be set in the range of 0.005 to 0.05 mg/l. EPA anticipates proposing additional RMCLs for other VOC compounds in the near future.

4.5.2.2 Groundwater Quality at Norton AFB

The applicable standards for the water quality analyses conducted at Norton AFB are summarized in Table 4-10. Table 4-10 also lists those monitor wells in which applicable standards were exceeded.

Of the dissolved metals included in the analyses (Pb, Cr, Ni, Cd, As, Zn, Cu, Hg; and Li in four wells) only lead and arsenic were found in concentrations exceeding drinking water standards. The highest level of dissolved lead (0.43 mg/l) was encountered in MW-4 in Zone 1, the highest level of arsenic (0.35 mg/l) was encountered in MW-10 in Zone 4. Both metals have a FPDWS of 0.05 mg/l.

No enforceable standards exist for cyanide or phenol, or for the general indicator parameters TOC (Total Organic Carbon) and TOX (Total Organic Halogen). TOC is a generalized screening parameter used to detect organic contaminants. Background levels of TOC in groundwater are usually below 1.0 mg/l, although it is not uncommon for TOC in shallow water-table aquifers to range above 10 mg/l. When TOC concentrations rise above 10 mg/l, there is a general indication of contamination; however, the elevated levels may be caused by natural phenomena including vegetative decay.

At Norton AFB, the TOC contamination indicator level of 10 mg/l was exceeded in two Zones, the highest level (41.6 mg/l) was found in MW-15 in Zone 3. In Zone 6 (AAVS/DAVA) the downgradient wells exhibited TOC levels of 10.8 to 18.1 mg/l, while the upgradient well (MW-19) had a TOC level of only 3.5 mg/l.

TOX is an indicator parameter of halogenated organic compounds. These compounds are synthetic and do not occur naturally, so there is no naturally occurring background level in groundwater for them. It is possible for volatile compounds contributing to TOX concentrations to leach from PVC well construction materials, but this possibility is compensated for by purge-pumping wells prior to sampling. Generally, however, any level of TOX indicates some type of man-made chemical contamination. Because more than half of the USEPA list of volatile organic Priority Pollutants are halogenated, the TOX parameter provides a method of screening samples for these contaminants before proceeding to specific analyses (Harper, 1984). TOX levels encountered

TABLE 4-10: COMPARISON OF GROUNDWATER RESULTS WITH APPLICABLE STANDARDS, GUIDELINES AND CRITERIA

PARAMETER	WATER QUALITY STANDARD	REFERENCE	MONITOR WELLS AT OR EXCEEDING STANDARD
Field pH	6.5-8.5	(2)	None
Specific Conductance (umho/cm)	None	--	Not applicable
Metals (mg/l)			
Lead	0.05	(1)	MW-4, 9, 14, 18 (3)
Chromium	0.05	(1)	None
Nickel	None		
Cadmium	0.01	(1)	None
Arsenic	0.05	(1)	MW-10
Zinc	5.0	(2)	
Copper	1.0	(2)	None
Mercury	0.002	(1)	None
Lithium	None	(6)	Not applicable
Cyanide (mg/l)	0.10	(1)	None
Phenol (mg/l)	None	--	Not Applicable
Oil and Grease (mg/l)	None	--	Not Applicable
TOC (mg/l)	None	--	Not applicable
TOX (mg/l)	None	--	Not applicable

References for Water Quality Standards

(1) Federal Primary Drinking Water Standard
(2) Federal Secondary Drinking Water Standard
(3) Monitor Wells MW-14 and -18 only marginally exceed the FSDWS of 0.05 mg/l, and, within the margin of error for the analytical method, may actually be less than the FSDWS.

at Norton AFB ranged from below the detection limit of 0.005 mg/l up to 0.228 mg/l in MW-15 (Zone 3). TOX levels in the Zone 6 downgradient wells ranged from 0.051 to 0.145 mg/l. The TOX level in MW-14 (Zone 5) was 0.127 mg/l, and in MW-20 (Zone 4) it was 0.125 mg/l.

As noted above, it is anticipated that the USEPA RCMLs for many VOAs will be set in the range of 0.005 to 0.05 mg/l. In light of this, VOA concentrations above 0.05 mg/l in water should be considered of concern. The results of the VOA analyses (Table 4-6) indicate that this level is exceeded for at least one compound in the following wells: MW-15 in Zone 3, MW-14 in Zone 5, and MW-16, MW-17 and MW-18 in Zone 6.

4.5.3 Pond Quality (Zone 1)

On the basis of the pond water and bottom sediment results (Tables 4-8 and 4-9) and the above discussions on soil and water quality, there appears to be no significant contamination of either of these media in any of the ponds for the parameters analyzed. The following discussion is provided for evaluation of the fish tissue results. Available references for comparison include Hesse and Evans (1972), Kleinart and others (1974), Lucas and others (1970), Lovett and others (1972).

Metals uptake by fish may occur by direct absorption from the water column or through the food chain. Bioaccumulation factors many times the environmental exposure are possible. Since metals concentrations in the water column were not detectable except for lead in Pond 3, uptake from the food chain is assumed. Such a pathway may originate by sediment contamination. However, no data on sediment metals concentration were available.

Tissue concentrations of metals in fish collected in the three ponds are generally within the range of values reported in the literature for similar organisms from other waters. In some cases, comparison tissue metal levels are presented in the literature based on wet weight. For the purpose of this report, all values have been converted to dry weight, based on a conservative wet to dry weight ratio of 4:1. No arsenic or lead was found in any of the pond fish samples, and consequently these metals are not discussed further.

Nickel levels found at 1.2 ug/g, and only in Pond 1 fish samples, are well within the typical nickel concentration of edible fish tissue. Concentrations in fish from other waters range from 0.08 to 15.2 ug/g. No tolerance limits for nickel in edible fish flesh have been established by the U.S. Food and Drug Administration (USFDA).

Chromium levels, ranging from 0.38 to 0.79 ug/g, and found in all three ponds, were within background concentrations. In fish tissues from other waters concentrations range from none detected to 4.24 ug/g. No tolerance limits for chromium in edible fish flesh have been established by the USFDA.

Cadmium levels found at 0.5 ug/g in fish from both Ponds 1 and 2 are within typical background ranges. Cadmium residues in fish tend to be fairly uniform. Cadmium concentrations in fish tissues from other waters range from none detected to 1.2 ug/g in presumably whole fish samples. No tolerance limits for cadmium in edible fish flesh have been established by the USFDA.

Copper levels, ranging from 2.0 to 4.8 ug/g, and found in fish samples from all three ponds are within typical background ranges. In other areas, copper concentrations range from 0.8 to 13.8 ug/g in presumably whole fish samples, and from 6.0 to 112.0 ug/g on a liver basis (Lucas, et al, 1970); and from 2.0 to 5.12 on a dressed fish basis. No tolerance limits for copper in edible fish flesh have been established by the USFDA. However, the Canadian Food and Drug Directorate has established a limit of 100 ug/g in edible fish flesh.

Zinc levels, ranging from 34.4 to 201 ug/g, were found in fish samples from three ponds. These levels are within typical ranges in fish from other waters, with the notable exception of the young-of-the-year sunfish. Such variation may be related to the propensity for the smaller fish to feed on items in the food chain with a greater concentration of zinc. It is also possible, however, that the analysis of the whole fish (due to its small size) as opposed to the edible fillets analyzed in other samples, or the small sample size itself, may have biased the results. Other zinc values in this group were similar and more typical of fish from other waters. The zinc content of fish from other waters ranges from 0.2 to to 64.4 ug/g in dressed fish and from 24.0 to 180 ug/g in whole fish (Hesse and Evans, 1972). No tolerance limits for zinc in edible fish flesh have

been established by the USFDA. However, the Canadian Directorate has established a limit of 100 ug/g for edible fish flesh.

Mercury levels found at 0.03 ppm, and only in Pond 2 fish samples, are within typical background concentrations. In other waters, mercury concentrations range from none detected to 5.2 ppm in presumably whole fish samples between 0.2 and 44.8 ppm for dressed fish. The U.S. FDA and Canadian Directorate have established a tolerance limit of 0.5 ppm mercury, wet weight (approximately 0.13 ppm dry weight) for edible fish flesh.

Based on these results, no significant contamination of either the water bodies or the pelagic (water column) fish species appears to be occurring in any of the ponds sampled. In the absence of data on metal concentrations from either the sediments or benthic (bottom) fish species, no judgement can be made regarding these possible uptake compartments. For this reason, eating of bottom fish species (i.e. carp, drum, catfish, etc.) is not recommended.

4.6 CONCLUSIONS

Based upon the results of the Phase II, Stage 1 Confirmation Study conducted at Norton AFB, the following key conclusions have been drawn:

1. Groundwater in the principal valley aquifer occurs under shallow water-table conditions in the eastern and northeastern half of the Base, and under semi-confined conditions in the western and southwestern half. In the western and southwestern half, the principal aquifer is overlain by a shallow water-table aquifer approximately 5 to 20 feet thick, and separated from it by a silt and sandy silt zone from 3 to 12 feet thick.

2. Regional groundwater flow beneath the Base in the principal aquifer is to the west-southwest, approximately parallel to direction of the Santa Ana River, along an average hydraulic gradient of 0.008. Flow velocity in the principal aquifer is estimated to be relatively high (on the order of 10 feet/day) based on the permeable nature of the Tertiary and Quaternary alluvium underlying the valley. The regional flow direction may be

affected locally by pumping in the principal aquifer from high-capacity production wells both on and off-Base.

3. Flow direction in the shallow water-table aquifer along the southern and southeastern boundary is undetermined at this time, and may vary considerably during the course of the year. In July 1984, flow appeared to be occurring to the northwest, away from the Santa Ana River channel.

4. The influence of pumping wells screened in the principal aquifer represents the most likely potential for off-Base migration of contaminants. The location of major supply wells, both on and off-Base, is shown in Figure 2-6. The Gage Canal Company well field, located just off-Base between Zone 4 and the Santa Ana River channel, represents the most likely receptor for contaminants migrating off-Base.

5. The results of the GPR survey indicate that several apparent areas of disturbed subsoil exist in Zone 1, but that some of these areas may actually represent buried remnant channels of the Santa Ana filled with coarse, bouldery sediments. The most likely area of buried fill is Site 3, Waste Pit No. 2, in the Golf Course Parking Lot.

6. On the basis of groundwater and pond results, there do not appear to be significant levels of environmental contamination at most sites in Zone 1. The only Zone 1 sites considered for further investigation in the IRP are Site No. 3 (Waste Pit No. 2) on the basis of the GPR survey and the high specific conductance in MW-3, and Site No. 5 (Fire Protection Training Area No.2) on the basis of the soil boring results. Soil contamination was encountered in all six borings at Site No. 5, primarily with fuel-derivative volatile organic compounds in the 1 to 100 ug/g range, and secondarily with volatile chlorinated hydrocarbons in the 0.010 to 0.015 ug/g range. Four of the sites in this Zone have been buried since 1960, and are located either directly beneath ponds or under heavily irrigated portions of the Golf Course.

It is likely that any contaminants originally present in these sites have been dispersed by the high rates of percolation presumably associated with Golf Course irrigation, which would account for the relatively low levels of contaminants observed in monitor wells MW-1 through MW-8. No further action is warranted at sites 10 and 12 in Zone 1.

7. On the basis of groundwater results for MW-11 through MW-13, there do not appear to be significant levels of environmental contamination requiring remedial action in Zone 2, the Landfill Waste Management Zone.

8. On the basis of groundwater results for MW-15, there appears to be significant contamination of groundwater in Zone 3, Site No. 6, the Underground Waste Oil Storage Tank. This contamination is primarily represented by the chlorinated hydrocarbons (trans)1,2-dichlorethylene and TCE in the 0.4 to 1.0 mg/l range, the solvent MEK (0.043 mg/l), and fuel derivatives in the 0.040 to 0.70 mg/l range. Given the proximity of two Base production wells (33 and 34) to this site, these levels are considered to be of concern.

9. On the basis of soil and groundwater results, two sites in Zone 4 appear to have environmental contamination present: Site 7, the Sludge Drying Beds, and Site 17, Drummed Water Storage Area No. 3 and the Waste Fuel and Solvent Sumps. MW-10, located directly south of Site 7, exhibited a somewhat elevated level of TCE (0.04 mg/l,) and a high level of arsenic (0.35 mg/l). No significant levels of contamination were detected in the other three wells in Zone 4. Two boreholes drilled south of the Waste Fuel and Solvent Sumps in the Drummed Waste Storage Area (Site 17), however, exhibited elevated levels of soil contaminants, principally chloro- and dichlorobenzenes, in the range of 1 to 100,000 ug/g (as estimated from saturated detector). Given the proximity of the Base boundary in a downgradient direction, and the Gage Canal Company well field, these levels are considered to be of concern. The potential for off-Base migration of contaminants from this site is very high.

10. On the basis of groundwater results for MW-14, there appears to be significant contamination of groundwater in Zone 5, Site 14, Waste Pit No. 4, primarily with the volatile organic solvents TCE and MEK in the 0.012 to 0.23 mg/l range. Given the proximity of Base production well 33 to this site, these levels are considered to be of immediate concern.

11. On the basis of groundwater results in Zone 5, groundwater immediately downgradient from the AAVS/DAVA Evaporation Basins appears to be significantly contaminated with the breakdown products of organic volatile solvents (vinyl chloride and (trans) 1,2-dichloroethylene) in the 0.01 to 0.45 mg/l range. Relatively high values of specific conductance indicate that some contamination with inorganic salts not included in the Phase II Stage 1 analyses may also have occurred, most likely related to disposal of brines in these ponds. Given the proximity of Base well 35 to this Zone, observed contamination levels are considered to be of concern.

12. On the basis of Base-wide Phase II groundwater results, there appears to be no widespread contamination with dissolved metals, although localized incidents of metals contamination were observed.

SECTION 5

ALTERNATIVE MEASURES

5.1 GENERAL

The principal goal of the Phase II, Stage I Confirmation Study at Norton AFB was to determine whether or not environmental degradation was occurring as the result of past practices of materials handling or disposal at Norton AFB. The conclusions presented in Section 4 confirm that nine of the fifteen sites investigated have affected groundwater or soils in their immediate area. These are preliminary findings, based upon a single set of analyses, which require additional verification.

Concept engineering evaluation of remedial action alternatives was not part of this scope of work. The alternative measures discussed below focus mainly upon further actions to be taken toward problem definition aspects of confirmed environmental contamination at Norton AFB. The alternative actions to be discussed at this point fall into the following categories:

Action	Zone	Site
1. Monitoring at Base production wells		Base production wells
2. Verification sampling of groundwater at existing monitor wells	All zones	All sites
3. Routine water quality monitoring by the Base	1 2	4 (Waste Pit No. 1) 2 (Landfill No. 2)
4. Additional site geophysical investigation	All zones	3 (Waste Pit No. 2) 5 (Fire Protection Training Area No. 2) 6 (Underground Waste Oil Storage Tank) 17 (Drummed Waste Storage Area & Waste Fuel Sol-vent Sumps) 14 (Waste Pit No. 4) 16 (AAVS/DAVA Evaporation Basins)

5. Expanding the groundwater monitoring network	1	3 (Waste Pit No. 2)
	1	5 (Fire Protection Training Area No. 2)
	3	6 (Underground Waste Oil Storage Tank)
	4	7 (IWTP Sludge Drying Beds)
	4	17 (Drummed Waste Storage Area and Waste Fuel and Solvent Sumps)
	5	14 (Waste Pit No. 4)
	6	16 (AAVS/DAVA Evaporation Basins)
6. Additional soil sampling and analyses	4	7 (IWTP Sludge Drying Beds)
7. Expanded analytical protocol	3	6 (Underground Waste Oil Storage Tank)
	4	17 (Drummed Waste Storage Area and Waste Fuel and Solvent Sumps)
	5	14 (Waste Pit No. 4)
	6	16 (AAVS/DAVA Evaporation Basins)
8. Preliminary concept engineering evaluation	3	6 (Underground Waste Oil Storage Tank)
	4	17 (Drummed Waste Storage Area and Waste Fuel and Solvent Sumps)
	5	14 (Waste Pit No. 4)
	6	16 (AAVS/DAVA Evaporation Basins)

These alternative measures are discussed by zone in the following sections. Based upon the possible alternatives discussed here, specific recommendations are presented in Section 6.

5.2 ZONE-SPECIFIC MEASURES

5.2.1 Zone 1 - Alternative Measure

Two sites requiring further evaluation have been identified in Zone 1: Site 3 (Waste Pit No. 2) and Site 5 (Fire Protection Training Area No. 2). Site 3 requires further evaluation on the basis of GPR results, which appear to indicate significant subsoil disturbance beneath the parking lot. Preliminary groundwater quality results for some wells are inconclusive because the flow direction in the shallow water-table aquifer is undetermined at this time. One additional well located northwest of Waste Pit No. 2 (as defined

by the GPR Survey) and completed in the water-table aquifer is required to complete the Stage 1 confirmation study of this site. This well could be used for additional flow analysis and to sample groundwater in an alternate direction from the site for the same parameters as in Round 1, including dissolved metals.

Site 5 requires further evaluation based on very high levels of VOA compounds detected in shallow soil borings. A well cluster consisting of a shallow well in the perched water-table zone and a deep well in the principal aquifer, located immediately downgradient (southwest) of the burn area is required to complete the Stage 1 confirmation study for groundwater contamination.

Site No. 4 requires additional water quality monitoring in order to detect any future migration of lead which may occur. This monitoring can be accomplished by the base outside the IRP.

5.2.2 Zone 2 - Alternative Measures

Groundwater quality results for Zone 2 give no indication of significant groundwater degradation in this zone, although elevated lead and traces of tetrachloroethylene were detected in the monitor wells. Additional monitoring of these wells should be done on a routine, low-frequency basis to detect any future contaminant migration which may occur. This monitoring can be accomplished by the Base outside the IRP.

5.2.3 Zone 3 - Alternative Measures

Significant groundwater contamination appears to be associated with Site 6, the Underground Waste Oil Storage Tank, based on groundwater quality results from MW-15. Given the proximity of Base production wells 33 and 34, which supply water for human consumption, this site potentially represents a threat to human health if it causes contamination of a public water supply. Due to the complex subsurface geology and the depth of these production wells (1,100 and 818 feet respectively), a relatively large number of wells will be required to adequately define the distribution of contamination, both laterally toward the production wells and in the natural downgradient direction, and vertically between the level of the buried tank and the production well intakes. At least 8 additional monitor wells screened at increasing depths away from the site should be considered to adequately evaluate the magnitude and extent of contamination in the vicinity of this site.

Furthermore, given the variety of contaminants detected in the vicinity of this site, including both fuel derivatives

and solvent compounds, a number of unreported wastes may have been disposed of in this tank. The sampling protocol for groundwater should be expanded to include the full U.S. EPA Priority Pollutant List in order to properly evaluate the magnitude of groundwater contamination associated with this site.

A preliminary concept engineering evaluation should be performed to develop and evaluate options for proper remediation of the site.

5.2.4 Zone 4 - Alternative Measures

Two sites requiring further evaluation have been identified in Zone 4: Site 7, the IWTP Sludge Drying Beds, and Site 17, The Drummed Waste Storage Area and Waste Fuel and Solvent Sumps. These sites represent a potential impact to human health given the proximity of the Gage Canal Company well field just outside the boundary to the south. The direction of groundwater flow in the shallow water table aquifer immediately underlying Zone 4 is undetermined at this time, but flow in the principal aquifer is almost certainly influenced at this distance by pumping from the well field.

Site 7 may be contributing TCE, other volatiles, and metals to the ground based on groundwater results in MW-10, located just south of the site. Soil borings drilled directly through the sludge to a depth of 10 feet could be used to sample soils directly beneath the site for both VOA compounds and metals, to confirm contribution of contaminants to the subsurface from this site.

Site 17 has contributed significant levels of contaminants to the subsurface, particularly in the southern portion of the site based on soil quality results from two of the six borings drilled at this site. Contamination appears to have occurred both as a result of spillage and leaks from drums and discharge from the sumps. Primary contaminants on this site are chloro- and dichlorobenzenes. Although high levels of VOA have not been detected in any of the existing monitor wells in Zone 4, the source appears to be rather localized, and a plume could be moving south toward the well field between existing wells MW-10 and MW-20. At least two well clusters consisting of 1 shallow and 1 deep monitor well would be required, on a line with the nearest production well, to properly evaluate flow directions and the presence or absence of contamination related to this site in the water-table and principal aquifers. Due to lack of documentation or types of wastes disposed of at the site, it is recommended that the groundwater sampling protocol for this

site include the full list of U.S. EPA Priority Pollutants. A preliminary concept engineering evaluation should be conducted to develop and evaluate options for proper closure and remediation of the site. In any event, the Base should cease using the Waste Fuel and Solvent Sumps for disposal of any wastes immediately.

5.2.5 Zone 5 - Alternative Measures

This zone corresponds to site 14, Waste Pit No. 4. Groundwater Contamination, primarily with solvents, is confirmed at the site based on sampling at MW-14. Due to the proximity of this site to Base production wells 33 and 34, it represents a potential impact to human health.

A thin, shallow water-table aquifer apparently exists in the area, at least seasonally. For this reason, well clusters consisting of one shallow and one deep well will be required to adequately assess groundwater flow directions and the magnitude and extent of contamination areally and vertically. At least 5 well clusters should be considered, including at least two on a line connecting site 14 to the two nearby production wells. Due to the undetermined and undocumented nature of wastes discharged at the site, the analytical protocol for groundwater samples should include the full list of U.S. EPA Priority Pollutants. A preliminary concept engineering evaluation should be conducted to develop and evaluate options for proper closure and remediation of the site.

5.2.5 Zone 6 - Alternative Measures

Zone 6 corresponds to Site 16, the AAVS/DAVA Evaporation Basins. Although these basins were reportedly used only for disposal of inorganic thiosulfate brines, groundwater contamination with VOA compounds (primarily vinyl chloride and (trans)1,2-dichloroethane) has been confirmed in groundwater immediately downgradient from the site. An expanded groundwater monitoring network including at least three additional downgradient wells (one in line with Base production well 35) would be required to assess the magnitude and extent of contamination. Due to the undocumented nature of wastes disposed at the site, the groundwater sampling protocol should be expanded to include the full list of U.S. EPA Priority Pollutants and inorganic thiosulfate. A preliminary concept engineering evaluation should be performed to develop and evaluate potential remedial and proper closure alternatives for the site.

SECTION 6

RECOMMENDATIONS

The findings of the Phase II Confirmation Study, including GPR surveys, soil sampling, and groundwater sampling and analysis at fifteen sites at Norton AFB indicate the need for follow-up investigation at seven of these sites in five of the waste management zones. Routine monitoring of two additional sites by NoAFB should also be done. The two sites ranked highest on the basis of their HARM scores in the Phase I Report do not have significant levels of environmental contamination associated with them.

The following section reviews both general and Zone-specific recommendations made for follow-up action.

6.1 GENERAL RECOMMENDATIONS

Two general recommendations are made for actions to precede any further Zone-specific investigations:

1. Many of the findings and recommendations reported herein are based on a single round of groundwater samples. It is recommended that all twenty-two monitor wells be re-sampled in a second, verification round, that all the same parameters be analyzed for, and that the analysis results be compared to the first-round results before implementation of the Zone-specific recommendations.

2. All three of the active Base production wells (Nos. 33, 34, and 35) are located within 3,000 feet of at least one site recommended for further investigation. Wells No. 33 and 34 are located within 1,000 feet of Zone 3, the Underground Waste Oil Storage Tank. It is recommended that all three Base Production wells also be sampled during the second round of groundwater sampling, and that the samples be analyzed for field pH, specific conductance (SC), TOC, TOX, oil and grease and VOA at a minimum.

3. Surface geophysical surveys, including at least an Electromagnetic Conductivity (EM) survey, should be performed at all sites where additional monitor wells are recommended. Based on contrasts in electrical conductivity of groundwater observed in Stage 1, it should be possible to track plumes of contamination downgradient from the sites to guide placement of additional monitor wells.

6.2 ZONE-SPECIFIC RECOMMENDATIONS

Assuming that the findings reported based on the first round of sampling and analysis are verified by the second round, the following recommendations are made for follow-up investigation on a Zone-by-Zone basis.

6.2.1 Zone 1 - Recommendations

Two sites in the Golf Course Waste Management Zone are recommended for further investigation: Site 3, Waste Pit No. 2, and Site 5, Fire Prevention Training Area No. 2. In addition, a recommendation is made for Base monitoring of Site 4 (Waste Pit No. 1).

1. It is recommended that a magnetometer survey be performed at all sites where high priority targets were identified in the GPR Survey, in order to ascertain whether the targets identified are likely to be metallic (i.e. conductive) drums rather than rock boulders.

2. At Site 3, one additional monitor well should be installed adjacent to the site location as confirmed by the GPR Survey described herein. This well should be located directly northwest of the pit and screened in the shallow water-table aquifer at approximately the same depth as MW-3. The well should be surveyed and the water level measured and compared to the level in MW-3 to confirm the direction of the hydraulic gradient at the time of sampling. Both wells should be sampled concurrently for all parameters tested in Round 1, including dissolved metals.

   The rationales for installing a second well include the following: GPR results indicated a disturbed subsoil; specific conductance was high in MW-3; and the direction of shallow groundwater flow cannot be determined from the single existing monitor well. Unlike the other golf course sites, this site was paved over, and may still be generating leachate despite 24 years of burial.

3. At Site 5, a pair of monitor wells should be installed directly downgradient from the burn area in a west-southwesterly direction. The deep well should be screened below the silt zone at approximately the same depth as MW-9. The shallow well should be screened above the silt zone between 20 and 25 feet, and should include a sump, or blank

pipe, extending 5 feet below the screen into the silt. The annular space around the sump should be adequately sealed to prevent downgradient migration through the silt. It is recommended that this well be drilled and sampled during the wet winter months. Parameters to be sampled in both wells and in MW-9 should include field pH, SC, oil and grease, TOC , TOX and VOA compounds plus xylene and MEK.

The rationale for installing a new well cluster at this site is to monitor downgradient migration of contaminants in groundwater, whereas MW-9 monitors off-Base migration. The shallow well wil'. monitor perched groundwater should it occur at least seasonally above the silt zone. A sumped well is considered preferable to a suction lysimeter for determination of VOA compounds, assuming that a saturated perched layer is encountered.

4. At Site 4, the Base should undertake a routine, semi-annual water quality monitoring program for monitor wells MW-1, MW-2 and MW-4. The analyte of concern is lead. The purpose of this monitoring is to detect any downgradient migration of lead which may occur in the future, but which is not documented by results to date. No further IRP actions are recommended for this site.

5. No further action is warranted at Sites 10 and 12.

6.2.2 Zone 2 - Recommendations

At Site 2, Landfill No. 2, the Base should undertake a routine, semi-annual water quality monitoring program for monitor wells MW-11, MW-12, and MW-13. The analytes of concern are lead and VOA compounds. The purpose of this monitoring is to detect any migration of these compounds which may occur in the future, but which is not documented by results to date. No further IRP actions are recommended for this Zone.

6.2.3 Zone 3 - Recommendations

This Zone corresponds to Site 6, the Underground Waste Oil Storage Tank. The following actions are recommended:

1. Eight additional monitor wells should be installed, screened in the upper portion of the principal aquifer, with total screened depth increasing away from

the site. It is recommended that two monitor wells be located on a northerly line connecting Site 6, the Underground Waste Oil Storage Tank, with Base production well 34, and two on a south-southwesterly line with Base production well 33. The other four additional monitor wells are to be placed along two lines radiating approximately down the direction of natural gradient, to the west and southwest. All nine wells should be sampled for field pH, SC, oil and grease, TOC, TOX, and VOA compounds plus xylene and MEK. The monitor well exhibiting the most degraded water quality is recommended for sampling and analysis of the complete list of U.S. EPA Priority Pollutants.

The rationale for installing a network of monitoring wells around this site is to determine the magnitude and extent of confirmed groundwater contamination at this site, and the potential impact to human health, if any, related to the potential contamination of Base production wells.

2. A preliminary concept engineering study should be conducted to evaluate suitable remedial actions and options to obtain proper remediation and full closure of the site.

6.2.4 Zone 4 - Recommendations

This zone consists of the IWTP compound. Two sites are recommended for further investigation based on findings in this report: Site 7, the IWTP Sludge Drying Beds, and Site 17, the Drummed Waste Storage Area and Waste Fuel and Solvent Sumps (currently in the process of being closed). One factor strongly influencing recommendations made for this Zone is the presence of the Gage Canal Company well field just outside the Base boundary immediately to the south of Zone 4. Pumping in this well field is thought to influence the hydraulic gradient, at least in the principal aquifer. Additional monitor wells should be used to determine the gradient and direction of flow in both the shallow water-table and principal aquifer, as well as evaluate the presence or absence of contamination and its extent in groundwater.

1. All legally available information on the Gage Canal Company well field should be collected, including exact well locations, well construction details, lithologic logs, production rate and operating schedule and any records of sample analysis.

2. Four soil borings should be drilled through the Sludge Drying Beds (Site 7) to a depth of ten feet. They should be sampled continuously, and samples analyzed for oil and grease, metals, and VOA compounds plus MEK. This sampling program will serve to better define the contribution of contaminants to the subsurface from the unlined drying beds. Should Gage Canal Company records indicate that other contaminants are, or have been, detected in the well field, then this analytical list would be recommended for modification.

3. A total of four additional monitor wells should be installed in two clusters, one directly south of Site 17 (between that site and the Base boundary), and one off-Base on a direct line with the nearest active Gage Canal Company well. The shallow wells in the cluster should be screened, above the silt zone at depths comparable to MW-10 and MW-20 through MW-22. The deep wells should be screened below the silt zone, with total screened depth increasing away from the site.

   The wells should be sampled for field pH, SC, oil and grease, TOC, TOX, and VOA compounds plus MEK and xylene. The monitor well having the most degraded water quality should be sampled for analysis of the complete list of U.S. EPA Priority Pollutants.

4. A preliminary concept engineering study should be conducted to evaluate suitable remedial actions and options to obtain proper closure of the site.

5. The Base should cease usage of the Waste Fuel and Solvent Sumps immediately, and ensure that all waste fuels and solvents are removed from the sumps.

6. No further evaluation of the IWTP discharge ditch is warranted.

6.2.5 Zone 5 - Recommendations

Zone 5 corresponds to Site 14, Waste Pit No. 4, in the Civil Engineering compound (currently in the process of being closed).

1. Nine additional monitor wells should be installed in five clusters (including existing well MW-14), five in the shallow water-table zone to be equipped with sumps, and four in the principal aquifer. Total screened depths of the deep wells should increase

away from the site. Two of the clusters should be on lines connecting the site with Base production wells 33 and 34, the remaining three radiating away from the site to the west and southwest in the direction of the natural gradient. The wells should be sampled for field pH, SC, TOC, TOX, and VOA compounds plus MEK. The monitor well exhibiting the most degraded water quality should be sampled for analysis of the complete list of U.S. EPA Priority Pollutants.

2. A preliminary concept engineering study should be conducted to evaluate suitable remedial actions and options to obtain proper closure of the site.

6.2.6 Zone 6 - Recommendations

Zone 6 corresponds to Site 16, the AAVS/DAVA Evaporation Basins. These basins were reported to have received only water softening brines and thiosulfate wastes, although Phase II Stage 1 findings indicate they are also associated with groundwater contamination involving VOA compounds.

1. Three additional monitor wells should be installed and screened at a depth equivalent with the existing monitor wells (MW-16 through MW-19). They should be installed in a quarter circle to the west and southwest at a radius of 700 to 800 feet from the basins. One well should be located on a westerly line connecting the site with Base production well 35. The wells should be sampled for field pH, SC, oil and grease, TOC, TOX, VOA compounds plus MEK, cyanide (to test for disposal in wet wells located immediately southwest of DAVA), and the inorganic anion thiosulfate. The well exhibiting the most degraded water quality should be sampled for analysis of the complete list of U.S. EPA Priority Pollutants.

2. A preliminary concept engineering study should be conducted to evaluate remedial actions and options to obtain proper rehabilitation or closure of the site.

6.3 SUMMARY OF RECOMMENDATIONS

The recommendations described above have been summarized on a site-by-site basis in Table 6-1.

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TABLE 6-1

SUMMARY OF RECOMMENDATIONS

Zone	Site	Recommendation	Rationale
(General)		Resample 22 existing monitor wells	Verify Stage 1 results
		Sample 3 Base production wells	Evaluate human health hazard via drinking water
1	1, 3, 4 10, 12	Magnetometer Survey EM Survey	Verify GPR targets as metallic. Track downgradient contamination
	3	Install 1 shallow monitor well adjacent to and northwest of confirmed site	Test for contamination in alternate downgradient direction
	4	Base initiate routine monitoring	Detection of contaminant migration
	5	EM Survey	Track downgradient contamination
	5	Install 1 cluster of 1 shallow and 1 deep well directly west-southwest of burn area	Test for groundwater contamination in perched and principal aquifer
2	2	Base initiate routine monitoring	Detection of contaminant migration
3	6	EM Survey	Track downgradient contamination
	6	Install 8 additional monitor wells	Magnitude and extent of contamination
	6	Concept Engineering Evaluation	Remedial action and its closure
4		Obtain all available information on Gage Canal Company wells	Evaluate human health hazard via drinking water

TABLE 6-1 (cont.)

SUMMARY OF RECOMMENDATIONS

Zone	Site	Recommendation	Rationale
4	7	Drill 4 soil borings through sludge drying beds	Test for soil contamination
	17	EM Survey	Track downgradient contamination
	17	Install 2 well clusters including 1 well each in shallow water-table and principal aquifer	Magnitude and extent of contamination
	17	Concept Engineering Evaluation	Remedial action and site closure
5	14	EM Survey	Track downgradient contamination
	14	Install 1 shallow well and 4 clusters of 2 monitor wells each, including 1 each in shallow water-table and principal aquifer	Magnitude and extent of contamination
	14	Concept Engineering Evaluation	Remedial action and site closure
6	16	EM Survey	Track downgradient contamination
	16	Install 3 additional monitor wells	Extent and magnitude of contamination
	16	Concept Engineering Evaluation	Remedial action and site closure

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